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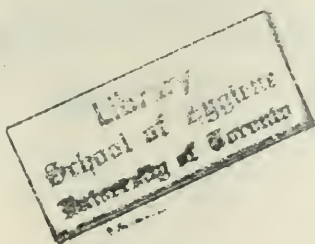
MAY, 1921

TOP MINNOWS IN RELATION TO MALARIA
CONTROL, WITH NOTES ON THEIR
HABITS AND DISTRIBUTION

BY

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FOREWORD.

At the request of the Public Health Service the Bureau of Fisheries kindly cooperated with the service in carrying out studies of malaria control, by detailing Mr. Samuel F. Hildebrand to undertake studies of the relation of fishes to the control of mosquito breeding.

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TOP MINNOWS IN RELATION TO MALARIA CONTROL WITH NOTES ON THEIR HABITS AND DISTRIBUTION.

INTRODUCTION.

The seriousness of malaria as a disease in the Southern States of this country generally has not been realized in the past, and, since it is the immediate cause of death less frequently than a number of other diseases, it has not received the attention which it justly deserves. Dr. H. R. Carter, Assistant Surgeon General, United States Public Health Service, who, because of his many years of close study and extensive experience, is well qualified to speak as an authority on the subject, says:¹ "In the United States where it seriously prevails it is the most injurious of all diseases. I do not except typhoid, nor for the South, pellagra, nor tuberculosis. * * * First, malaria is one of the diseases that debilitates and thus increases the fatality of other diseases. I am very sure it is a factor in many deaths in which it is not the terminal factor. I think it causes many more deaths than are ascribed to it. Nor is the number of deaths a fair criterion, a fair measure, of the damage that a disease does. Surely the disability that it causes, the loss of efficiency, is of importance. * * * And it is the amount of malaria that appals. There is so much of it where it exists. If you have half of 1 per cent typhoid cases in a city in a year, you count it as an epidemic, or a serious problem. Five per thousand; certainly that is serious. We scarcely consider malaria to prevail unless we have at least 10 to 12 per cent of cases a year; 25 per cent is common and 50 per cent is not rare, and at times we find 90 to 100 per cent. * * * Prosperity is not compatible with the prevalence of malaria. That is true of few diseases. Take yellow fever. I would by no means belittle the damage it does, but it does not do the harm to the community that malaria does. Habana was a prosperous city with endemic yellow fever. New Orleans was prosperous with many epidemics. But I defy you to show me one single place inhabited by white people where malaria seriously prevails which is prosperous. It does not exist."

The human suffering, the loss of life as well as the financial loss due to malaria, however, are becoming better understood and very commendable efforts are now being made by various communities

¹ Public Health Bulletin, U. S. Public Health Service, No. 105, 1920, pp. 40 and 41.

in several Southern States to control malaria. Health officers are devoting much attention to methods of malaria control. The old and well-established methods of screening houses, the draining of water deposits, and the application of oil on potential mosquito-breeding areas are still extensively used, and recently malaria control by the use of top minnows for destroying the immature mosquito has received considerable attention. It is the purpose of this paper to report the results obtained by the use of minnows as an agent in the control of malaria and to show how and when this method of control may be used.

The results hereafter recorded are based upon observations and experiments made mostly during the summer of 1920 by the writer working in cooperation with the United States Public Health Service, and in a few instances, reports, received from sanitary engineers who employed minnows for mosquito control, are quoted.

The period from March 4 to August 15, 1920, was spent mostly in inspecting various localities in 11 Southern States where active anti-malaria work was under consideration or already under way. Suggestions were given to those in charge of antimalaria projects for the use of top minnows in their respective territories. Those water deposits which appeared suitable for fish control were pointed out, and an endeavor was made to find a supply of minnows locally. Usually a body of water suitable for propagating top minnows was selected in each locality and designated a "hatchery." The latter part of the season, viz, from August 15 to November 13, was devoted almost exclusively to investigations at Savannah, Ga.²

SPECIES OF FISHES CONSIDERED.

Experiments and observations made to date indicate that at least the following four species of fishes inhabiting the Southern States, or some portion thereof, are of more or less value in eradicating mosquito larvæ and pupæ: *Gambusia affinis*, *Heterandria formosa*, *Fundulus notti*, and *Fundulus notatus*. A fifth species, *Mollienesia latipinna* which is of no value in antimalaria work, but which has much in common with *Gambusia affinis* with respect to its habits and general appearance, at least when seen in the water, and which has not always been distinguished from the very valuable *Gambusia affinis* by field men, will also be discussed.

CHARACTERIZATION OF THE SPECIES.

All of the species of fishes mentioned in the preceding paragraph belong to the minnow family *Poeciliida*, which is characterized prin-

² I am greatly indebted to many officers, Federal, State, county, and municipal, for favors and courtesies received, and especially to Drs. Brunner and Bassett of the city health department of Savannah, Ga., for laboratory facilities and other conveniences which they placed at my disposal.

cipally by the elongate body, which is depressed or flattened anteriorly and compressed posteriorly; the lateral line is absent; the mouth is terminal and capable of being projected; only one dorsal fin composed of soft rays is present; the ventral fins (the fins corresponding to the hind legs of higher animals) are inserted on the abdomen, and the caudal or tail fin is square or convex, never forked.

The following key gives the principal characters by which the species discussed in this paper may be recognized.

a. Top of head plain, without greenish or yellowish spot or "star;" body rather short and plump; species viviparous, i. e., giving birth to live young; males much smaller than females; anal fin of adult male developed into a long process which is used as an intromittent organ.

b. Color plain grayish silvery, the sides without dark lines along the rows of scales; caudal fin usually with vertical series of dark spots; gravid females with a black spot on abdomen above and in advance of vent; alimentary canal without convolutions, shorter than body; dorsal fin small, with 7 to 9 rays; females reaching a length of about 60 millimeters ($2\frac{3}{8}$ inches).

Gambusia affinis.

bb. Color grayish silvery, each scale on side (except in very young) with a dark spot, forming longitudinal dark stripes along the rows of scales; caudal fin plain, usually without dark spots; gravid females never with black spot on abdomen; alimentary canal greatly convoluted, about 3 times the total length of the fish; dorsal fin large, greatly elevated in adult males, consisting of 13 to 16 rays; females reaching a length of 76 millimeters (3 inches).

Molliensia latipinna.

bbb. Color grayish green; sides with a black lateral stripe and with about eight narrow vertical bars; caudal fin plain; dorsal and anal fins in females each with a prominent black spot at base, dark spot on base of anal wanting in males; gravid females with a small elongated black spot on abdomen above and in advance of vent; alimentary canal not convoluted, shorter than body; dorsal fin small, with 7 or 8 rays; females reaching a length of 30 millimeters ($1\frac{1}{4}$ inches).

Heterandria formosa.

aa. Top of head with a greenish or yellowish spot or "star" (this "star" is very evident when the fish is seen in the water); body quite elongate; species oviparous, i. e., the eggs are laid, fertilized, and hatched outside the body; the male not notably smaller than the female; anal fin of the male normally developed.

c. Sides with about 6 narrow longitudinal dark stripes and with about 12 narrow vertical bars; a dark bar on cheek under eye; fins all plain, unspotted.

Fundulus nottii.

cc. Sides with a broad longitudinal dark band, more or less broken up into blotches in young; dorsal, caudal, and anal fins dotted with black.

Fundulus notatus.

GAMBUSIA AFFINIS.

DISTRIBUTION.

Gambusia affinis is the most widely distributed and by far the most important fish known for mosquito control. It inhabits all of the southern States east of the Rocky Mountains and its range of distribution extends northward to Delaware and southern Illinois

and Indiana. It was readily found in nearly all localities visited where antimalaria work was carried on during the summer of 1920. It, however, is principally a lowland species, and, in general, its distribution is limited to the malarious sections. The vicinity of Austin, Tex., for example, may be considered outside of the malarious

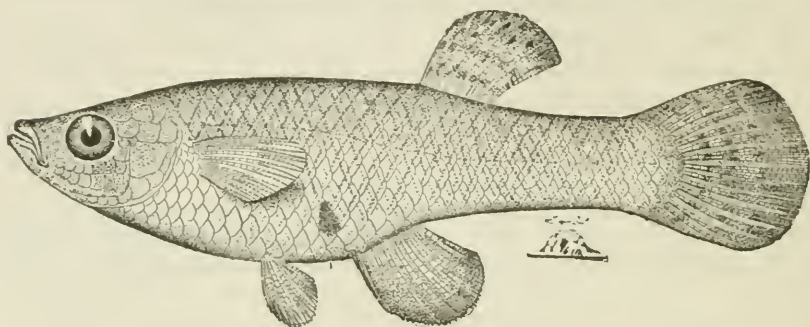


FIG. 1.—*Gambusia affinis* (female).

belt of Texas, and while a limited number of apparently suitable waters occur there only a very few individuals were found after a thorough search made by a representative of the Texas State Board of Health. A similar situation prevails in Atlanta, Ga., and apparently also at Nashville, Tenn. The lower sections, or the malarious belts of the States in which the above-mentioned cities are situated, as well as those of all other southern States, as far as

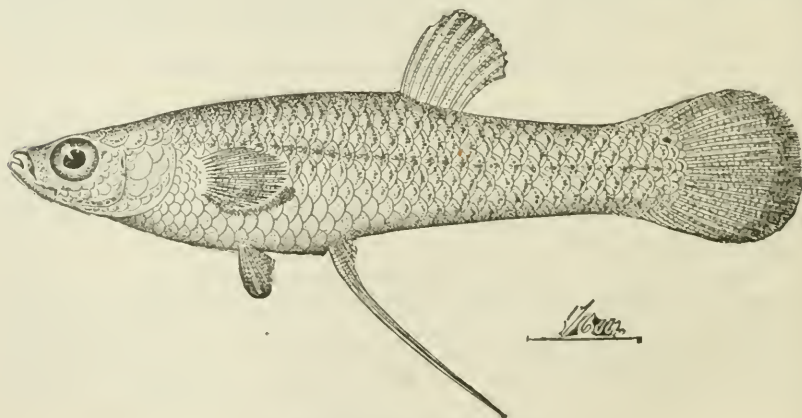


FIG. 2.—*Gambusia affinis* (male).

observed, are well supplied with *Gambusia affinis*, the species having reached nearly all sluggish and standing waters which were accessible to it through natural channels. However, there are bodies of water, artificial and others, which are inaccessible to the fish, and such waters are usually prolific producers of mosquitoes.

HABITAT.

It is improbable, regardless of being limited in its distribution principally to the lowlands, that any other American fish lives under a wider range of conditions than *Gambusia affinis*. It inhabits all kinds of sluggish and standing water, whether fresh or brackish, whether clear or muddy, whether deep or shallow. This fish, although frequenting deep water, at least when large fish are not present, shows a distinct preference for shallow water, and it is frequently seen in water too shallow to completely cover its body. This shallow water during the summer often becomes uncomfortably warm to the human touch. The top minnow probably seeks the shallow waters partly because of its fear of larger fish and undoubtedly also because the quiet, shallow places produce more food of the kind sought by *Gambusia*. It thrives in ponds visited by cattle, horses, and hogs, also in weak to moderately strong sewerage, escaping from city mains; it is found alike in open water and in that which is overgrown by vegetation, and it even withstands a small amount of chemical pollution. *Gambusia affinis* survived in ditches, at Savannah, Ga., receiving the wastes from a "guano" factory which killed such hardy species as the common fresh-water eel, the mudfish or bowfin, and the catfishes. *Gambusia*, however, endures less chemical pollution, particularly acid, than such species of mosquitoes as *Anopheles crucians*, *Aedes sollicitans*, and *Culex* (species undetermined).³ *Gambusia* has been introduced into cisterns, water tanks,⁴ potholes, barrels, and aquaria, where it has lived for long periods of time.

The habitat of the fish, therefore, is such that it corresponds quite closely with that of the immature mosquito.

SPAWNING HABITS.

Gambusia affinis reproduces very rapidly. As already stated, it is viviparous. The eggs are fertilized and hatched within the body of the female, and the young are brought into the world well developed and alive, being from 8 to 10 millimeters ($\frac{3}{16}$ to $\frac{2}{5}$ inch) in length and eminently fitted to begin the destruction of mosquito larvæ immediately. The female has broods of young throughout the summer at intervals of from three to six weeks, the length of the breeding season varying with the latitude and somewhat with the weather conditions

³ A water sample taken at a point on a ditch at Savannah, Ga., where the pollution from the guano factory was as great as *Anopheles crucians* appears to use for breeding purposes, was tested for free acid by Dr. Bassett of the city laboratory, and it was found to contain 2.08 per cent of acidity and much iron. *Aedes sollicitans*, however, bred where the chemical pollution was much greater. A water sample taken where the pollution had become dilute enough to support *Gambusia* contained only a trace of free acid and very little iron.

⁴ It has been reported by Mr. W. E. Hardenburg, assistant sanitary engineer, U. S. Public Health Service, Bryan, Tex., and Mr. E. H. Magoon, sanitary director, International Health Board, Groveton, Tex., that *Gambusia affinis* will not live in metal tanks or cisterns nor in water taken from them.

of the different years. The breeding season, for example, begins about the middle of May and ends near the middle of September at Beaufort, N. C.; at Augusta, Ga., it begins about the first of May and ends the first of October; while at Key West, Fla., breeding occurs at all seasons, although gravid females are much less numerous during the winter than during the summer.

The number of young produced at one time varies greatly, ranging from a few to a couple of hundred. The largest single brood heretofore recorded consisted of 100⁵ young, but the writer recently found broods which greatly exceeded that number comprising, respectively, 120, 163, and 211 young. It is of interest to note that the females producing these very large broods all were from the same pool at Savannah, Ga., where they first attracted attention because of their large size (49, 58, and 59 millimeters (2, 2 $\frac{1}{4}$, and 2 $\frac{1}{2}$ inches) in length), the enormous distension of the abdomen, and the abnormally large black spot on the abdomen. The pool was connected with a sanitary sewer, but the water was not very foul. The sewer, nevertheless, insured an abundant food supply, which probably explains why the fish reached a large size and produced large broods of young. The average number of young to a brood, however, probably does not exceed 40, the number usually varying with the size of the female, i. e., a small female gives birth to a smaller brood than a large female. The young fish grow rapidly and become sexually mature in the aquarium at the age of about four months and quite probably in a shorter time under favorable conditions in their natural habitat. It is very important in estimating the rate of reproduction to know that *Gambusia affinis* reaches sexual maturity at a very early age. Aquarium experiments have given results which show that one female during a single season may have 345⁶ offspring, consisting of two generations. Results obtained in propagating this fish indicate that this high rate of reproduction is maintained in ponds used for cultural purposes.

FEEDING HABITS.

Gambusia affinis, in addition to living under a wide range of conditions under which mosquitoes propagate, has the very fortunate habit for the purpose of mosquito control of seeking its food at the surface of the water, where the immature mosquito spends most of its life and to which it must come for air.

This fish shows a distinct preference for live bait, but it is not limited thereto for sustenance, as it eats small pieces of meat of all kinds, also bread and cracker crumbs, hard-boiled egg, etc. It takes these foods, when they are provided, in its natural habitat as well as in the

⁵ Smith, H. M., Science, N. S., Vol. XXXVI, 1912, p. 224.

⁶ Hildebrand, Samuel F., Report U. S. Commissioner of Fisheries, Appendix VI, 1917, p. 11.

aquarium. When such foods float at the surface, and, more especially, while they are in motion, as in sinking, they are usually eagerly attacked, but when they once reach the bottom they are generally left until other parts of the water have been thoroughly searched. The feeding experiments just mentioned show that by instinct *Gambusia* searches for food at or near the surface and on the bottom only when food is not available elsewhere.

The examination of stomach contents of a large number of *Gambusia* taken at Savannah, Ga., during August, September, October, and November, 1920, verified former observations, viz, that insects and insect larvæ constitute a large part of the food, but the majority of the stomachs examined contained some plant tissue, consisting mostly of algæ. The comparatively large amount of plant tissue found in several specimens precludes the probability that it was taken by accident in the capture of animal prey. It, therefore, is quite evident that *Gambusia affinis*, at least occasionally, eats plants.

The sense of smell seems to be very imperfectly developed in *Gambusia affinis* and it does not appear to be of any use whatever to the fish in its search for food. Sight, too, appears to lack high development, for it has often been observed that this fish will "nose" live prey, such as mosquito larvæ, and frequently move away from it, leaving it undisturbed. On the other hand, it is not unusual for *Gambusia* to seize a small stick floating on the water which resembles in size and shape an *Anopheles* larva, but such sticks are immediately expelled, and, so far as the writer has observed, they are never swallowed. It has also been observed that occasionally dead mosquito larvæ are taken but not swallowed. Live larvæ, when once seized, invariably are devoured. The writer, for the purpose of determining whether or not *Gambusia* preferred live or dead mosquito larvæ, introduced into the aquarium with a pipette both live and dead ones. The dead wrigglers upon being expelled from the pipette were in motion, and they therefore were seized by the fish and occasionally they were swallowed, but usually they were expelled. Sometimes they were resealed and reexpelled three and four times and not devoured as long as live larvæ were available.

Gambusia, as already indicated, is attracted by movements in the water, which it appears to be able to detect very quickly, but its range of vision in this respect for mosquito larvæ appears to be limited to a radius of about four or five inches. The movement of large prey is more quickly noticed than that of small prey. The wiggling of a large mosquito larva, for example, is noticed more readily than that of a small one, and this almost invariably results in the destruction of the large larvæ first. The instinct of following and capturing moving or wiggling animals is possessed by young fish when born, for it has been demonstrated repeatedly that young

just born are at once attracted by the movements of wiggle tails, exactly as is the adult. The ability of *Gambusia affinis* to readily detect moving objects in the water constitutes the most important faculty of sense possessed by this fish, as it thereby obtains most of its food and also gains at least a measure of protection from enemies. It of course is this sense of motion, together with the ability of capturing moving animals in the water, which makes *Gambusia* a real enemy of the wiggle tail.

On the other hand, it is quite certain that the immature mosquito, particularly the larva of *Anopheles*, is aware of the dangers of wiggling in the presence of fish. It has been noticed many times that mosquito larvæ remain very quiet when minnows are near and when a slight movement would mean certain death.⁷ The immature mosquito even appears to have acquired a very definite sense of the proper time to make a move. When placed in open water, where minnows are present, an *Anopheles* larva very rarely makes any movement whatever, but if a hiding place from fish is near it makes a surprisingly rapid dash for the place of protection at the critical moment when no fish is very near or between it and the object which it desires to reach.

Gambusia affinis has a large capacity for food consumption, as it is not unusual for one fish in the aquarium to eat over 100 large mosquito larvæ in one day. The number of mosquito larvæ which one fish may consume at one time, of course, bears a direct relation to the size of the fish, as well as the size of the larvæ. A small minnow obviously is able to consume fewer larvæ of the same size than a large minnow. Recently a large female, 59 millimeters ($2\frac{1}{3}$ inches) long, which had been fed with wiggle tails rather regularly from day to day for several weeks, took within an hour 225 large immature mosquitoes, about one-third of which were pupæ. A large male, 30 millimeters ($1\frac{1}{4}$ inches) long, held under the same conditions, consumed only 28 larvæ and pupæ, while fish three months old and 18 millimeters ($\frac{3}{4}$ inch long) ate 4 wiggle tails, the pupæ being too large for fish of this size to swallow. The appetite of young fish just born is satisfied by one small to medium-sized wiggle tail. Young *Gambusia* frequently attack wiggle tails nearly half as long as the fish themselves. Much difficulty, of course, is encountered in swallowing a morsel of such prodigious size, a portion of the larva frequently projecting from the fish's mouth for several minutes after the swallowing process is begun.

Much greed often is displayed by *Gambusia* in the aquarium. When several mosquito larvæ are introduced at one time, this minnow

⁷Hildebrand, Samuel F., Public Health Reports, U. S. Public Health Service, vol. 34, No. 21, 1919, p. 1123, or Report U. S. Commissioner of Fisheries, Appendix IX, 1919, p. 12.

snaps up the wiggle tails faster than it is able to swallow them and it is not unusual for the larva previously caught to escape from the mouth of the fish as it strikes for another. These feeding experiments show that *Gambusia*, of all sizes and ages, readily feed on mosquito larvæ, and they furnish the basis for an idea of the enormous destruction of immature mosquitoes which *Gambusia* may accomplish.

FIELD EXPERIMENTS AND OBSERVATIONS.

Gambusia affinis is by far the most important natural enemy of the immature mosquito known to date. Its value as an agent in the control of the mosquito is becoming widely recognized, and it was used with success in 1920 by sanitary engineers and others in at least 10 Southern States. It was shown in the foregoing pages of this paper that the natural habitat of *Gambusia* corresponds quite closely with that of the immature mosquito in the malarious sections of the South. The distribution of the fish, however, is limited to the waters to which it has had access through natural channels and to the few other waters to which it has been recently transferred artificially. The mosquito, on the other hand, is able to reach practically all bodies of water, and because of its short life in the aquatic stages it is able to utilize for breeding purposes temporary waters which are not suited to support fish life. The value of *Gambusia* as an eradicator of mosquito larvæ, therefore, may be ascertained by the inspection of quiet waters which support top minnows and of those in the same locality which do not support top minnows for the purpose of determining which waters produce the largest number of mosquitoes. The value of *Gambusia* as an agent for the control of mosquitoes may also be demonstrated by stocking certain waters which are infested with mosquito larvæ and then results may be awaited and observed. A very convincing experiment may be made by stocking with *Gambusia* one of two similar bodies of water situated in the same locality, neither of which previously supported top minnows, both, however, being infested with mosquito larvæ. The body of water which is not stocked with fish will serve as a "control," which will furnish a fair comparison. Occasionally it is possible to demonstrate in a very convincing way the destruction of mosquito larvæ which *Gambusia affinis* accomplishes by connecting by means of a ditch one body of water which is heavily infested with mosquito larvæ with another pond supporting top minnows. The above-mentioned experiments have been made within recent years by various representatives of State Boards of Health, the United States Public Health Service, the International Health Board, and by the United States Bureau of Fisheries. The results in all cases have been almost identical, and they leave absolutely no doubt concerning the great value of *Gambusia affinis* as an agent for the control of malaria.

The presence of small mosquito larvæ in waters inhabited by top minnows is not unusual, and their presence is considered merely as showing definitely that mosquitoes are breeding in these waters, but, unless large larvæ and pupæ also are present, no production is taking place, and mosquito control obtains. It is of record that rarely a body of water is found which apparently is well suited to support *Anopheles* larvæ but which the mosquitoes do not appear to use for breeding purposes.⁸ It, however, is reasonable to assume that usually, at least, when no wiggle tails are found in a pond stocked with top minnows that the fish are providing control, and it has been learned through experiments and observations that when food for fish is scarce and good protection for the immature mosquito against fish is not available, then very frequently not even small mosquito larvæ are found in the presence of *Gambusia*.

The following observations, relative to the efficiency of *Gambusia affinis* as a factor in mosquito control are a few of the many similar ones made during the summer of 1920: A certain sluggish ditch at Gulfport, Miss., was inspected on May 19, 1920. The lower part of this ditch supported very few top minnows and some mosquito larvæ in protected places. Farther upstream the ditch divided. One of the branches was abundantly supplied with *Gambusia*, and not a single large mosquito larva was found. The other branch supported no fish at all, and wiggle tails were present in countless numbers. It was found upon investigation that the latter ditch received the wash from certain streets surfaced with the waste "iron pyrites" from chemical works, which so polluted the ditch that fish could not live. It is not reasonable to believe that the polluted ditch was more attractive to mosquitoes which came to deposit eggs than the unpolluted one. The fish, therefore, quite certainly provided mosquito control where they were present in sufficient numbers and where they were not hindered by pollution. On May 20 several disconnected pools and ditches were seen in the northern section of Gulfport, Miss., which were heavy producers of mosquitoes, but in not a single instance were top minnows present. The ditches in the same section which supported top minnows, however, were under perfect control. On May 24 a shallow pond on Court House Road, near Gulfport, Miss., which formerly had been connected with a drainage ditch, but which had become closed by the top of a fallen pine tree, was found to be well stocked with *Gambusia*, and no wiggle tails were present therein. The ditch beyond the pine top, where no minnows were present, was breeding *Anopheles* prolifically, the larvæ being visible in open water.

⁸ Le Prince, Joseph A., and Orenstein, A. J., Mosquito Control in Panama, p. 12. Putnam, New York and London, 1916.

Hildebrand, Samuel F., Public Health Reports, U. S. Public Health Service, vol. 34, No. 21, 1919, p. 1125, or Report U. S. Commissioner of Fisheries, Appendix IX, 1919, p. 13.

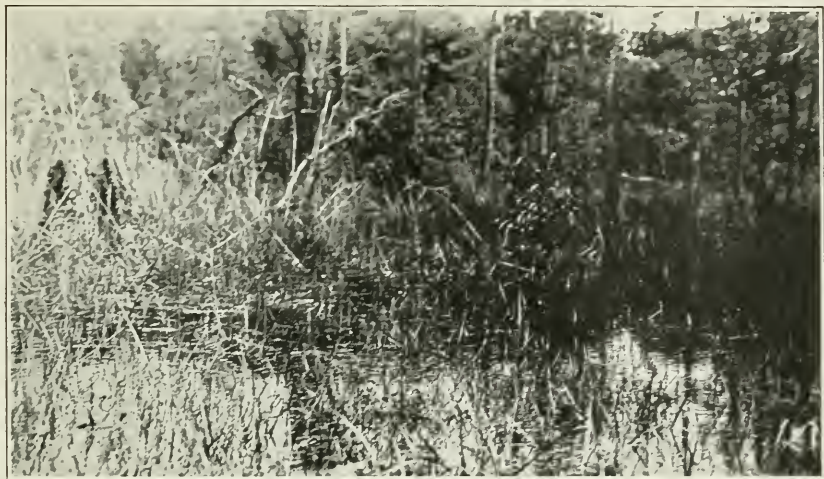


Fig. 3.—Section of pond, Gulfport, Miss., showing vegetable growth in water. Pond supports top minnows and no mosquito production was taking place at time of inspection when photograph was made, May 21.

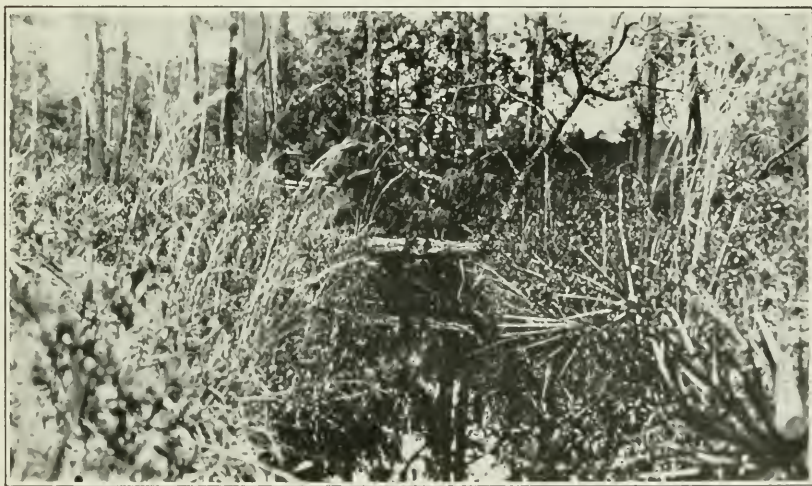


Fig. 4.—Section of ditch in pine woods, separated from pond shown in above photograph by pine top and drift. No top minnows and no vegetation in ditch, but it was a prolific producer of *Anopheles* at the time the inspection and photograph were made, May 21.



Fig. 5.—Pool left in bed of stream as water fell. No top minnows and no vegetable growth were present, but *Anopheles* larvae were rather plentiful when the pool was inspected and photographed, June 2. Photograph by E. H. Magoon.

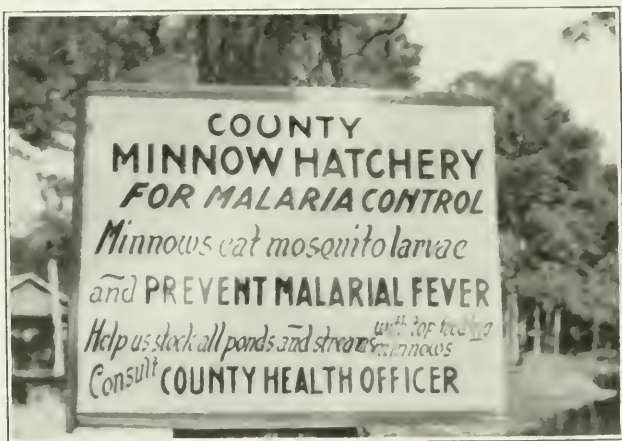


Fig. 6.—Sign erected at a pond at Thomasville, Ga. Photograph by H. N. Old.



Fig. 7.—Section of pond, Augusta, Ga., abundantly stocked with *Gambusia affinis*, but complete mosquito control did not prevail where the aquatic grass, shown in the photograph, was present. Photographed August 5.



Fig. 8.—Section of pond, Augusta, Ga., showing growth of aquatic grass (*Hydrochloa carolinensis*) in foreground. Complete mosquito control with fish rarely prevails where this grass is present.



Fig. 9.—Section of sawmill pond, Perry, Fla., showing a dense growth of marginal vegetation, consisting mainly of the small dense aquatic grass (*Hydrochloa carolinensis*). The top minnows *Gambusia affinis* and *Heterandria formosa* were both very abundant and apparently complete mosquito control prevailed throughout the season of 1920. Photographed August 10.



Fig. 10.—Ditch, Savannah, Ga., polluted by waste from guano factory seen in background. Vegetation consists mainly of the aquatic grass, *Hydrochloa carolinensis*. No fish present. A place of prolific mosquito production. Photographed October 29.



Fig. 11.—One of a series of ponds at Athens, Tex., which was used to demonstrate the reduction in malaria that may be gained by the introduction of top minnows. Photographed June 1.



Fig. 12.—Pond in pasture, Cameron, Tex., abundantly stocked with *Gambusia affinis* from which minnows for distribution were obtained. Photographed June 6.

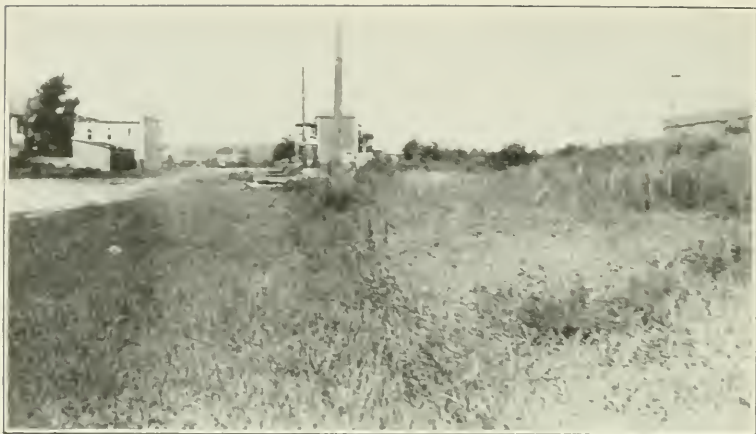


Fig. 13.—Ditch, Gulfport, Miss., overgrown with grass. *Gambusia affinis* abundant in water under grass. Mosquito control prevailed when inspected and photographed, May 21.



Fig. 14.—Ditch, Savannah, Ga., overgrown with primrose willows, *Jussiaea diffusa* and *Jussiaea leptocarpa*. Top minnows were abundant, but rarely was a large mosquito larva found in the dense root masses formed near the surface. Photographed October 22.

It was found on May 28, on the United States Public Health Service grounds at Houston, Tex., that top minnows were scarce in ditches on one side of a certain road, but plentiful on the opposite side. The ditches which supported few minnows bred some mosquitoes in protected places; the isolated pools which were without fish were heavy producers, but the ditches well supplied with *Gambusia* were free of mosquito larvæ. It is of interest to note that some oil had been used in the ditches nearest the hospital, and they supported few top minnows. No oil had been applied where the minnows were abundant, which indicates that even though top minnows are not killed by a film of oil, as used for mosquito control work, it nevertheless has the tendency to drive the minnows away. The oil undoubtedly is disagreeable to the fish and it destroys at least some of their food. It, therefore, does not seem practicable to use oil and fish in the same waters. It seems more advisable, when complete mosquito control does not prevail in the presence of minnows, to supply more fish or to remove vegetation and floatage, or both, rather than to resort to the application of oil as an auxiliary measure.

Two small, deep, completely isolated ponds at Athens, Tex., nearly identical in size, depth, and general appearance and situated side by side, were inspected on June 1. One of the ponds had been stocked artificially a short time previously with *Gambusia*. No mosquito larvæ were found in this pond, but they were quite common in the other one. Amusement was obtained by dipping mosquito larvæ from the latter and placing them among the minnows in the former in order to notice the quick destruction which the larvæ met in the presence of *Gambusia*. A certain creek discharging into a large saw-mill pond at South Groveton, Tex., was very low, leaving only isolated pools, at the time of inspection on June 3. Certain pools in this creek bed had been left, as the water fell, without top minnows, and these pools, although usually free of vegetation and floatage, were supporting *Anopheles* larvæ. The pools in which *Gambusia* was present were all free of immature mosquitoes.

A large series of ponds at Augusta, Ga., which was stocked with *Gambusia* during the antimalaria campaign of the extra-cantonment zone of Camp Hancock in 1918^o were inspected from August 4 to 6. It was found that no great amount of mosquito production occurred in any of the ponds and that most of them were under perfect control. A new pond on Milledgeville Road, constructed since 1918, which was not stocked with *Gambusia*, was a very prolific producer

^o For an account of the tests made in the extra-cantonment zone of Camp Hancock during the summer of 1918, see *Fishes in Relation to Mosquito Control in Ponds*, Illdebrand, Samuel F., Public Health Reports, vol. 34, No. 21, 1919, pp. 1113 to 1128, or Report U. S. Commissioner of Fisheries, Appendix IX, 1919, 15 pp., 3 figs., 6 pls.

of *Anopheles*. It was not unusual to take from 25 to 100 larvæ in a single dip. It is very certain that this single pond was producing many more mosquitoes than all the other ponds in that vicinity combined.

The natural distribution of top minnows at Savannah, Ga., owing to the low and flat nature of the land, is quite thorough, practically all ditches and swamps being stocked. A few ponds or swamps, because of artificial barriers, had not been reached by fish. Such places invariably were heavy producers of mosquitoes, while similar waters near at hand, but supplied with top minnows, invariably were under perfect control. When these heavy breeding areas were stocked with minnows complete mosquito control resulted in each instance within two weeks.

Certain ditches at Savannah, Ga., became polluted by acid waste from a "guano factory" during October, due to drainage operations which caused the current in the drain receiving the waste from the factory to become reversed, discharging its contents into unpolluted ditches. A series of ditches consequently became polluted, causing, as already stated, the death of mudfish, catfish, eels, etc., and it drove away the top minnows from the more strongly polluted ones. *Gambusia*, however, remained where the pollution was very dilute. Several species of mosquitoes, including *Anopheles crucians*, as already stated, were able to withstand more pollution than top minnows, and heavy mosquito production resulted in certain sections of the ditches where the pollution was somewhat diluted, yet too strong for *Gambusia*. These ditches were under almost perfect control when top minnows were present. A rather definite line afterwards marked the place where mosquito production ceased, which was coterminal with the line beyond which top minnows were unable to live because of the pollution. It, again, does not seem reasonable that the polluted portions of the ditches offered more favorable breeding conditions for the mosquito than the very slightly or entirely unpolluted portions. Therefore it seems quite certain that the top minnows, where they were present, were the agents which supplied mosquito control.

MOLLIENESIA LATIPINNA.

Mollienesia latipinna is a larger fish than *Gambusia affinis*, the female frequently reaching a length of about 75 millimeters (3 inches). Its range of distribution is very much smaller than that for *Gambusia affinis*, being limited to the low coastal plains from South Carolina to northern Mexico. It inhabits strongly brackish and fresh water swamps and sluggish ditches and streams. *Mollienesia* is usually very abundant within its range, and it frequently is found in company with *Gambusia affinis*, from which it is distinguished in

the water with difficulty because its general shape, color, and swimming movements when seen from above are very similar. The adult fish when removed from the water, however, is readily distinguished from *Gambusia affinis* by the dark lines along the rows of scales on the



FIG. 15.—*Mollienesia latipinna* (female).

sides, and the dorsal fin is notably longer, as shown in the preceding section of this paper, entitled "Characterization of the Species" (p. 8).

Mollienesia latipinna appears to produce broods of young with a somewhat larger numerical average than *Gambusia*, although to date the largest brood found is smaller than certain broods of the latter reported in the foregoing pages of this paper. Broods exceeding 100 in number were not unusual at Savannah, Ga., during August and September, 1920. The largest brood seen, consisting of 139 young, was produced by a female 73 millimeters long (nearly 3 inches). Aquarium experiments suggest that *Mollienesia latipinna* produces broods of young at greater intervals than *Gambusia*, but the short time devoted to these experiments was insufficient to produce definite results.

The young of *Mollienesia* at birth are notably larger than *Gambusia*, being from 11 to 12 millimeters ($\frac{1}{2}$ inch) in length. They grow rapidly, as certain young born August 26 had attained a length of 21 millimeters on November 8. The age and size at which this fish reaches sexual maturity is not known, but it probably does not differ greatly from *Gambusia*.

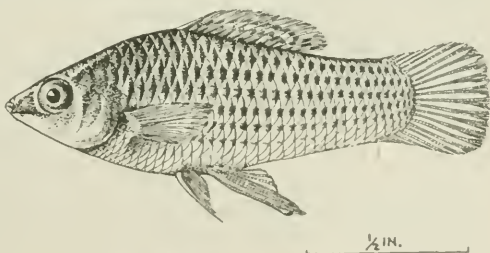


FIG. 16.—*Mollienesia latipinna* (male).

Mollienesia latipinna usually swims somewhat deeper than *Gambusia*, and the adults, at least, are seen less frequently in very shallow water. The species is much more timid and harder to catch than *Gambusia*, and, unlike the latter, it is very restless in the aquarium, and does not become tame.

Feeding tests in the aquarium and in a fountain and the examination of stomach contents show that this fish is almost wholly herbivorous, algæ constituting the principal food. *Mollienesia* is extremely abundant in the sewerage ditches at Savannah, Ga., where it feeds extensively on the organic matter delivered by the city sewers. *Mollienesia* did not feed on wiggle tails in the aquarium when green algæ, too, was supplied. It failed, after several weeks' trial, to provide mosquito control in a fountain only about 12 feet in diameter, which was under perfect control within two days after *Mollienesia* was removed and *Gambusia* substituted. These experiments show that *Mollienesia* feeds on mosquito larvæ only when its natural or usual food (that is, plants) is not available. It is therefore of very little value as an eradicator of mosquito larvæ, and may be disregarded in practical mosquito control work.

HETERANDRIA FORMOSA.

Heterandria formosa is probably the smallest American vertebrate.¹⁰ The largest female seen, which was an exceptionally large fish of its kind, measured 31 millimeters ($1\frac{1}{4}$ inches), in length, while the males rarely exceed a length of 20 millimeters ($\frac{3}{4}$ inch).

The range of distribution of this species is given in current works as extending from North or South Carolina to Florida. The Florida records, however, appear to be confined to the Atlantic drainage. The author recently found this fish in abundance at Perry, Taylor County, Fla., about 20 miles inland from the coast of the Gulf of Mexico, which appears to be the first time that this species was taken in the Gulf drainage.

Heterandria formosa has been found only in low coastal plains, but it runs somewhat farther inland than *Mollienesia latipinna* and usually is found in company with *Gambusia affinis*. Its habitat, however, appears to be rather definitely restricted to fresh-water swamps and ditches supporting a considerable amount of vegetation, among which it lives, seeks its food, and gains a measure of protection from enemies. *Heterandria* is easily overlooked, even where it is abundant, because of its small size, because it is seen at the surface less frequently than *Gambusia*, and because of its habit of usually remaining among vegetation.

¹⁰ Heun, Arthur W., American Naturalist, vol. 46, March, 1912, p. 161.

Heterandria formosa is an excellent aquarium fish. It is even more hardy than *Gambusia*, it has beautiful color markings, and it becomes tame very quickly. It may be taught, in a very short time, that taps on some portion of the aquarium indicate that food is to be provided at that point. A large pipette was used for introducing mosquito larvæ in the aquaria, and the fish very quickly learned to

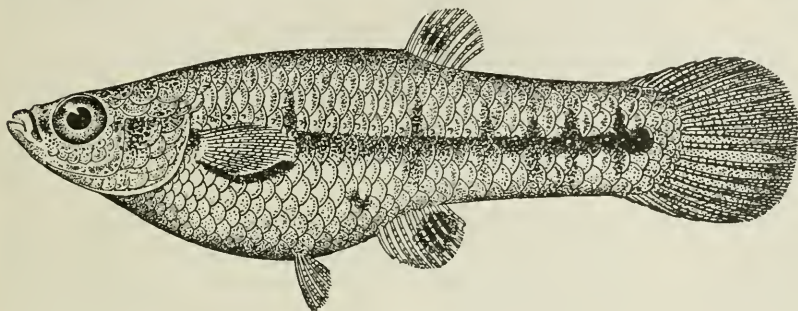


FIG. 17.—*Heterandria formosa* (female).

respond to taps and to take a position at the mouth of the pipette where they eagerly awaited the expulsion of larvæ. The wiggle tails were instantly seized upon being liberated and the introduction of other larvæ was anxiously awaited until the fishes' appetites became satisfied.

This species produces small broods of young, which consist of from two to nine fish, but new broods appear at frequent intervals. Females confined in aquarium jars in the city laboratory at Savannah, Ga., on August 25, 1920, had young at intervals varying from one to three weeks, until about the middle of October, when the spawning season ended. The ovary of this fish, during the breeding season, contains embryos of three or four distinct sizes. One lot of embryos, for example, may consist of fully developed fish which are about ready to begin an existence separate from the mother; another lot is notably smaller, and the embryos have a considerable amount of unabsorbed yolk; the third lot consists of small

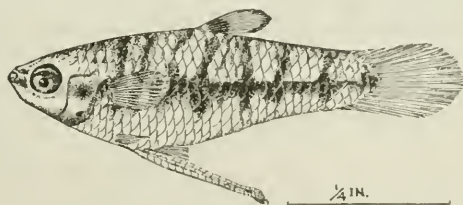


FIG. 18.—*Heterandria formosa* (male).

embryos which are still within the egg case; and the fourth lot consists of "eyed" eggs. At least two sizes of eggs, in addition to the embryos, are present within the ovary during the breeding season.

The young when born are well formed and active, but they are very much smaller than the newly born *Gambusia*, being only about 6 millimeters ($\frac{1}{4}$ inch) in length. Young born in the aquarium

on September 4 and fed rather regularly on a diet of bread crumbs and mosquito larvæ had attained a length of only 10 millimeters ($\frac{2}{5}$ inch) on November 8, when they were no larger than *Gambusia* at birth.

Heterandria formosa appears to feed on quite as many different kinds of foods as *Gambusia*, and it also shows a distinct preference for a live animal diet. It attacks and eats with avidity mosquito larvæ, but even the largest females have great difficulty in swallowing the pupæ. The newly born young, like those of *Gambusia*, are attracted at once by the movements of mosquito larvæ, and they follow and attack wiggle tails nearly as large as the little fishes themselves, but, of course, the young fish are able to swallow only rather small wrigglers.

Heterandria appears to be less cannibalistic in its habits than *Gambusia*. Certain broods of young were left in rather small aquarium jars with the mothers for several months and some of the young were not destroyed, while *Gambusia* invariably destroys all of her young under similar conditions within a few days. The adult *Heterandria* is frequently attracted by the movements of the young, and it gives chase, but apparently the young fish is not destroyed, provided that the mother distinguishes between her young and a wiggle tail before the little fish is actually seized. It certainly is true, however, that many species of fish, not naturally cannibalistic or even strictly herbivorous, will resort to cannibalism when other foods are not supplied. *Mollienesia latipinna*, which is normally herbivorous and which does not destroy wiggle tails if plant foods are present, will devour her own young in the aquarium when her appetite prompts her to resort to other than her natural foods. Therefore, it is necessary to supply sufficient natural foods to satisfy the fish's appetite, if the aquarium tests are to be indicative of the fish's natural tendencies relative to cannibalism.

Experiments and observations relative to the value of *Heterandria formosa* as an eradicator of mosquito larvæ have not extended over a sufficient length of time nor over a wide enough range of conditions to furnish definite information showing its relative value as an agent for the control of malaria. The experiments and observations which have been made, however, indicate that it is of real value under at least the limited range of conditions under which the tests were made. Two somewhat similar, shallow ponds, about 30 by 20 feet each, largely overgrown with vegetation and both heavy producers of mosquitoes, were stocked with this fish during the latter part of the summer of 1920. Perfect mosquito control resulted in each instance within about two weeks, and this control was maintained until the ponds went dry in October. Neither of these ponds presented especially difficult situations, as the vegetation consisted prin-

cipally of semiaquatic plants, which did not provide good protection for mosquito larvæ against fish. The low and flat nature of the land in the vicinity of Savannah, Ga., where these experiments were made, has resulted in a very general distribution of top minnows, leaving no permanent waters and only comparatively few temporary ones without fish. This situation precluded the opportunity of making tests under a wider range of conditions. Field observations in general yielded nothing very definite, because wherever *Heterandria* naturally occurred *Gambusia* also was present, and it was not possible to determine the respective parts provided by the two species in the very excellent control which generally obtained. However, it is absolutely true that not one place was seen, and many difficult conditions from the standpoint of mosquito control with fish were inspected both at Perry, Fla., and Savannah, Ga., where almost perfect mosquito control did not prevail in the presence of both species. The small size of *Heterandria formosa*, making it possible for this fish to reach places inaccessible to larger minnows,

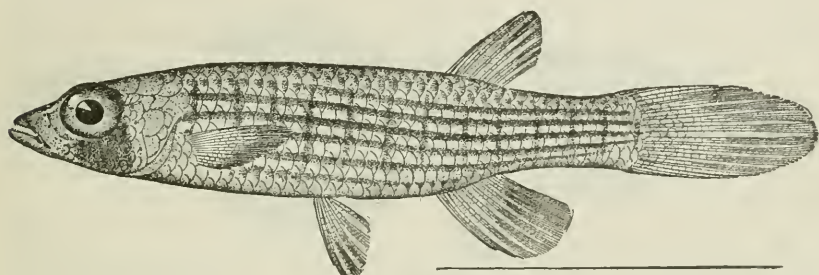


FIG. 19.—*Fundulus notti*.

together with its habit of living among vegetation, suggest that it may constitute a very important enemy of the wiggie tail, which seeks refuge among plants. The inspections and the experiments, while not very definite or extensive, as already shown, nevertheless indicate that *Heterandria* is a very serious enemy of the immature mosquito and that this fish is well worth serious consideration as an agent for the control of malaria.

FUNDULUS NOTTII.

Fundulus notti is known from sluggish streams and swamps from North Carolina, South Carolina, Georgia, Florida, and Alabama. It has not been seen by the writer in the low coastal plains, but it occurs somewhat farther inland. This fish is not as abundant within its range as the viviparous species discussed in this paper, and it is rather particular in its choice of locality. It appears to prefer ponds and swamps which support much vegetation, and it is not present in all waters accessible through natural channels in the regions where

it occurs. It is a very timid species, difficult to catch, and does not live well in confinement.

Nothing definite is known concerning the spawning habits of this species, but, since it lives among vegetation, it is supposed that the eggs are deposited in the vegetation or possibly attached to it. No practical tests relative to the value of this species as an eradicator of mosquito larvæ have been made. The supposition that it is of value as an agent for the control of malaria is based upon its habit of swimming at the surface and living largely among vegetation and upon certain rather unsatisfactory field observations.

FUNDULUS NOTATUS.

Fundulus notatus is much more widely distributed than *Fundulus nottii*, for it ranges from Michigan to Alabama and westward to Texas. Its habits in the South appear to be identical with *F. nottii* and our knowledge of its value as an eradicator of mosquito larvæ is equally as limited. It was found to be rather common in a certain

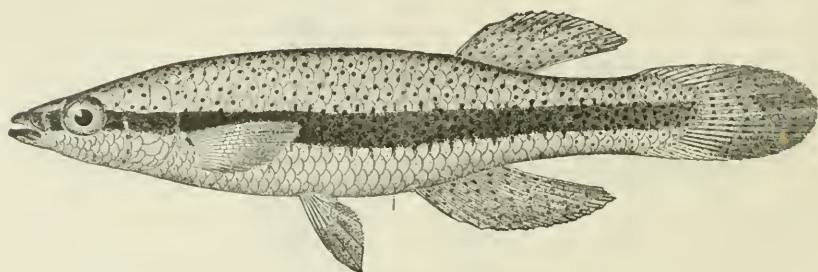


FIG. 20.—*Fundulus notatus*.

large pond at Jacksonville, Tex., where no other top minnows were present. The sanitary engineer in charge of antimalaria measures at this place reported that during the early part of the season of 1920 fairly good mosquito control prevailed in this pond, but during June mosquito larvæ appeared in such large numbers that it was thought necessary to introduce *Gambusia*.

It is extremely doubtful whether it will be practicable to use these egg-laying species, except in a very limited way, for the control of malaria, as they nowhere have been found in sufficient abundance to justify the expectation of complete mosquito control, and it will probably prove difficult to propagate them in large numbers.

PROPAGATION OF MINNOWS.

It has been found advantageous in many localities, where anti-malaria work was being carried on in the South in 1920 to designate particular bodies of water in which special effort was made to propagate minnows. Such ponds or "hatcheries" usually furnished a

convenient supply of minnows for transplantation from time to time into waters where additional fish were required. The hatcheries also afforded means of meeting requests for minnows received from individuals who wished to control mosquito breeding in waters on their respective premises.

The requirements for successful propagation of the egg-laying species *Fundulus nottii* and *F. notatus* are not known, but they undoubtedly need special conditions of environment for depositing and hatching the eggs. Propagating the viviparous species is very much simpler, as no special conditions for spawning are necessary, the young being born as the fish moves about in the water. Only two conditions appear to be essential in a body of water for the successful propagation of *Gambusia affinis*, viz., an abundant food supply, and protection from enemies. The most important enemies of the top minnows are the larger species of predacious fishes. The water snakes and birds, too, are enemies, and not infrequently bait collectors prove to be the worst offenders of all. Therefore, it is important to choose a body of water where the enemies are not present or where they can be controlled. Bodies of water with a considerable amount of plant growth usually supply abundant food for *Gambusia*, and they have been very successfully used as "hatcheries." Ponds in pastures visited by live stock have been used with especially good success, and water deposits in open fields and pastures generally have given better results than waters in wooded areas.

Health officers in a few instances have thought it advisable to advertise the "hatcheries" in their territories for the purpose of stimulating an interest in antimalaria work which would reach beyond the particular area used for demonstration purposes. In one instance a signboard reading as follows was erected: "County minnow hatchery for malaria control. Minnows eat mosquito larvæ and prevent malaria fever. Help us stock all ponds and streams with top-feeding minnows. Consult county health officer."¹¹ Such signs undoubtedly serve a useful purpose in educating the public in the use of this comparatively inexpensive antimalaria measure which is available throughout the malarious sections of the South.

PLANTS AND FLOATAGE IN RELATION TO MOSQUITO CONTROL BY THE USE OF FISH.

Large mosquito larvæ and pupæ frequently are found in waters where top minnows are plentiful, but only among plants or floatage of such a character as to provide refuge for the immature mosquito against fish. *Anopheles* larvæ particularly have highly developed

¹¹ This sign was erected at a pond on the Tallahassee Road at Thomasville, Ga.

the habit of hovering over slightly submerged objects. A mere film of water over a leaf or over a floating piece of wood is sufficient for the welfare of a mosquito larva, while it usually is impossible for a minnow to reach an immature mosquito in such a position. Mosquito larvæ and pupæ, however, have never been found by the writer to be very abundant even where excellent protection from fish was at hand, if *Gambusia* was really plentiful. It has not been determined how many of the large larvæ and pupæ found under the conditions just described actually escape the fish permanently and attain the adult stage. It was shown through feeding experiments, already described, that the movements of large prey are more quickly noticed by the minnows than that of small prey, and that in the aquarium large larvæ and pupæ invariably are destroyed before the small larvæ are noticed. The security of the immature mosquito in the presence of top minnows therefore depends upon how quietly and closely it adheres to places of protection.

Certain ponds at Augusta, Ga., previously mentioned, furnish a good illustration of the difference in mosquito production which may be expected when top minnows are plentiful and when they are absent. A pond on the Milledgeville Road, largely overgrown with aquatic grass, and not stocked with top minnows, was breeding *Anopheles* so profusely that frequently from 25 to 100 larvæ could be taken in a single dip with an ordinary water dipper. The larvæ in this pond were not confined to the densest vegetation alone, but they could be seen and collected from the open water. Numerous other ponds in the same vicinity, which were more densely overgrown with aquatic grass, but which were stocked with *Gambusia affinis*, yielded, at most, one immature mosquito to a dip, when the dippings were made in the densest growth of grass and no larvæ were present in open water. The illustrations just cited probably are typical and it shows the results which may be expected, even under adverse conditions, from the use of top minnows for mosquito control.

Plants with slightly submerged leaves, or slightly submerged floatage, which have enough water over them to support a wiggle tail, a mere film being sufficient, but not enough to permit a minnow to swim above them, are the chief protectors of immature mosquitoes against fish. The small aquatic grasses, particularly *Hydrochloa carolinensis*, are a source of considerable difficulty in securing complete mosquito control with fish.¹² Also the green scums, or algæ, when they form dense floating pads, very frequently furnish excellent refuge for the immature mosquito. Many other plants, some of them

¹² Carter, LePrince, and Griffiths, Public Health Bulletin, U. S. Public Health Service, No. 79, 1916, pp. 28 and 29.

Hildebrand, Samuel F., Public Health Reports, U. S. Public Health Service, vol. 34, No. 21, 1919, p. 1121, or Report U. S. Commissioner of Fisheries, Appendix IX, 1919, p. 10.

strictly aquatic, others of the shore variety, often cause imperfect control when they are partly or slightly submerged. Plants which normally are wholly submerged, such as *Chara*, *Najas*, certain species of *Myriophyllum*, and others, oftentimes reach the surface during seasons of drought and they then form hiding places for the immature mosquito against fish. Water lilies cause imperfect control when the broad leaves become partly submerged or when they at times hold water in the center, while the margin remains above the surface of the surrounding water. Marginal vegetation is of importance in relation to mosquito control only when having partly or slightly submerged leaves. Many of these plants interfere with mosquito control only after freshets, when the level of the adjacent water is raised, submerging them partly, and again when they mature and the seeds or the plants themselves fall into the water.

Certain plants, such as the floating primrose willows and the tall wire grasses, frequently develop a mass of roots near the surface of the water which fish can not penetrate, and therefore provide a limited degree of protection for the immature mosquito. It has also been reported¹³ that sunken leaves of trees, covering the sloping shores of a body of water, may gradually appear above the surface of the water as a lower water level ensues upon decreased rainfall and that they then cause serious trouble in maintaining mosquito control by the use of top minnows.

The tall plants with straight stalks and few leaves at or near the surface of the water, such as the rushes, cat-tails, etc., provide little or no protection for mosquito larvæ. Some of the smaller plants, as, for example, the duck weeds and certain water ferns, are not known to hinder mosquito control; they do not have dense root systems: their leaves float wholly upon the surface of the water; and therefore they furnish no refuge from fish for the immature mosquito. Observations indicate that these plants, when covering practically the entire surface of a body of water, may even prevent mosquito breeding. It is probable that the adult mosquito does not lay eggs among these plants, as frequently but little open water is present, and there is also a possibility that the eggs would be drowned by the more or less constant shifting of the weed masses as driven by winds or currents. The smartweeds, too, where they form a dense growth, appear to prevent mosquito production and it is probable that these weeds, because of their acrid nature, are offensive to the mosquito.

Since there are many conditions under which plants furnish protection for immature mosquitoes against fish, it is very essential in the conduct of antimalaria campaigns to make frequent and careful

¹³ This report was made by Associate Sanitary Engineer A. W. Fuchs of the U. S. Public Health Service.

inspections of all waters. If it is found that certain plants are preventing complete mosquito control, then it is time to aid the minnows. The indiscriminate cutting and clearing of vegetation from water deposits is certainly not an economical practice, as such work is frequently unnecessary. The biological condition existing in each body of water must determine whether or not top minnows will require assistance from man to secure control of mosquito production. The kinds and the density of vegetation growing in each water deposit, the abundance of top minnows, and the amount of food available for the fish must be carefully considered.

A certain small pond at Augusta, Ga., stocked with *Gambusia affinis* in extreme abundance, was inspected in August, 1920. The water along shore supported innumerable small organisms, just visible with the unaided eye, which undoubtedly form a very important part of the food of minnows, at least of the young fish. Large *Anopheles* larvæ were not uncommon in the aquatic grass which grew in the shallower parts of the water. Another pond only a few hundred yards away, supporting a denser growth of grass and possibly fewer minnows, but lacking the small organisms in corresponding abundance, was under almost complete control. A little later during August, 1920, certain ponds at Thomasville, Ga., and Perry, Fla., were inspected and the conditions with respect to dense growths of aquatic grass were found to be very severe, yet in each instance perfect mosquito control appeared to obtain. Later, almost perfect mosquito control was found in sluggish ditches at Savannah, Ga., under conditions equally as difficult.¹⁴ Top minnows in each instance were very abundant and food for the fish appeared to be scarce.

These observations show that minnows can and do sometimes furnish complete mosquito control under conditions which, superficially at least, are more adverse than others where such control does not obtain, and they led to the belief that if top minnows are abundant enough to create a real dearth of food, causing them to maintain a vigilant search for prey, mosquito control will then result even where extremely adverse conditions with respect to plant growths and floatage prevail.

An experiment was made at Savannah, Ga., during October, 1920, which gave at least limited proof of the supposition just stated. An isolated ditch, about 75 yards long and 3 to 4 yards wide, with growths of the aquatic grass (*Hydrochloa carolinensis*), creeping primrose willow (*Jussiaea diffusa*), pickerel weed (*Pondederia cordata*), the broad leafed arrowhead (*Sagittaria latifolia*), and a con-

¹⁴ *Gambusia affinis* alone of the top minnows was present at Augusta and Thomasville, Ga., but at Perry, Fla., and Savannah, Ga., *Heterandria formosa* and *Mollienesia latipinna* were also present.

siderable amount of filamentous alga, was found to support comparatively few top minnows and quite a few mosquito larvæ. On October 19 and 20, approximately 7,000 top minnows, consisting of *Gambusia* and *Heterandria* and a few *Mollienesia*, were introduced from another source. On October 30 every part of the ditch was thoroughly searched and only a single large mosquito larva was found. Mosquito breeding had not ceased in the meantime, as certain polluted ditches near at hand, supporting no fish, continued to produce mosquitoes prolifically. It is evident, therefore, that the almost complete control which resulted within 10 days after introducing the additional minnows was brought about by the fish.

Conditions undoubtedly prevail under which it would be difficult to materially increase the number of top minnows already present. If the minnows have been established in a body of water for a long time, they probably have reached the limit of reproduction which is permitted by the existing biological conditions. Yet it is sometimes feasible for the purpose of mosquito control to disturb such conditions and thereby secure an increase of minnows. The enemies of the minnows, for example, may be removed from a body of water, places of refuge may be constructed for the minnows, or food may be added to ponds used for propagating them.

Frequently perfect mosquito control prevails in the shallower parts of ponds even though much vegetation is present, while the control is much less efficient along the shore edges of the deeper parts supporting less vegetation. Top minnows show a natural preference for shallow water, which may have been acquired because of the disaster wrought by the larger fish when the minnows enter deep water. The result is that the minnows are more abundant in the shallower sections of a body of water than they are in the deeper ones, and consequently better mosquito control prevails in the shallower parts than in the deeper ones, if the latter are suited to mosquito production.

MALARIA CONTROL WITH GAMBUSIA AFFINIS AS THE SOLE AGENT.

An experiment which was calculated to show the measure of mosquito control that may be attained by the use of top minnows, assisted by the clearing of vegetation where necessary, was conducted at Athens, Tex., during the season of 1920. The area used for the experiment was comparatively free of temporary water deposits and seepage, the potential mosquito-breeding places consisting mainly of 19 artificial ponds. *Gambusia affinis* was abundant in a few ponds in the locality which were accessible to it through natural channels. The supply of minnows for stocking the other ponds was obtained

from these sources and from a sluggish stream a short distance from the city.

The following statements are quoted from a report by the sanitary engineer who had charge of the work:

"* * * A total of 14,720 *Gambusia* were placed in the 19 ponds mentioned. Their multiplication was rapid, and few *Anopheles* were found breeding up to the month of June, when heavy vegetable growth was completely removed. Four of these ponds were entirely free from this growth, due to their peculiar white clay banks. Dry weather, which followed, served to reduce the volume of water in the ponds, and the edges were entirely free from vegetation. *Anopheles* breeding was under control. Inquiry and observation proved that the mosquito nuisance had been greatly reduced.

"The effect of this work is best demonstrated by the following extract taken from a written statement made by Dr. J. K. Webster, city health officer, on September 1, 1920:

"'It is my observation that although there is more malaria in Athens this season than in previous years, there has been but very little in the area of mosquito-control work. In fact, in my own practice I have had no call to a case of malaria within the area of the work done.'"¹⁵

FISH CONTROL COMPARED WITH OTHER METHODS OF CONTROL.

Top minnows are of great value in controlling mosquito production in all permanent standing bodies of water, if in fact they are not the only agent known to date which successfully controls mosquito breeding in ponds and lakes. It has been demonstrated that top minnows are also very useful in sluggish ditches and streams, for at Savannah, Ga., all the ditches of the abandoned rice fields which supported top minnows, even though in many instances quite extensively overgrown with vegetation, were under almost perfect control during the latter part of the mosquito-breeding season of 1920, when the writer made inspections at frequent intervals. Identical results were observed under similar conditions earlier in the season of 1920 at Gulfport and Biloxi, Miss.; Wilmington, N. C.; and many other places. Minnows also are used in borrow pits, pools, potholes, cisterns, and shallow wells. Frequently it is feasible to use fish more economically than oil in temporary pools and ditches, depending upon how near at hand a supply of minnows is available and upon the length of time such temporary waters will remain. Probably it is seldom practicable to use fish when the waters dry up in less than a month, yet occasionally stocking a pool with fish is less expensive than one application of oil. Under such conditions it is an advantage to stock with fish pools remaining even a shorter period than one month. The situation with respect to the available supply of minnows and the cost of applying oil must determine in each instance which method is the more practi-

¹⁵ These remarks are from a paper read by Mr. George Parker, sanitary engineer with the International Health Board, before the conference of sanitary engineers held at Louisville, Ky., on Nov. 16 and 17, 1920.

cable. It is sometimes an advantage to dig a pit in the deepest part of a temporary pool or swamp which may hold enough water to carry at least some of the minnows through a period of drought.

Top minnows may be used under at least the following conditions where oil can not be used to advantage: (*a*) In ponds and lakes where a continuous film of oil cannot be maintained because of wind action, (*b*) in waters used for drinking purposes, whether for man or beast, where oil is objectionable, and (*c*) in places where certain types of vegetation which break the oil film are present, but which very frequently do not hinder mosquito control by fish. As already shown, conditions produced by plant growths exist under which absolute control with fish may fail, but under such conditions practically the same process of cutting and removing vegetation is necessary to secure control either with oil or with fish. Fish control, being of a much more enduring character than oiling, is therefore, preferable. It is well known that in order to secure mosquito control oil must be applied throughout the summer at intervals of from 7 to 10 days and during rainy weather oftener. The writer has not seen a permanent body of water where if the fish were once established they did not remain, unless killed or driven away by pollution. The many ponds at Augusta, Ga., which either were already stocked naturally or which were stocked artificially in 1918, were nearly all under perfect control in August, 1920, the fish in many ponds having multiplied greatly, while in others the biological limit of production had probably been reached in 1918.

The relative cost of mosquito control with fish as compared with control by the use of oil for a single season has not been well established, as no data based on somewhat similar situations have been collected. However, it is evident that if top minnows are available in a given locality (and they are abundant almost everywhere in the malarious sections of the South), the cost of fish control consists merely in distributing the fish, and in some instances the fish must be assisted by removing vegetation and floatage which furnish protection for the immature mosquito against fish. When oil is used, the cost of the product at present prices is a large item and the cost of distributing and spraying the oil at frequent intervals undoubtedly is greater than stocking with fish the waters within the same area, under the average conditions obtaining in the malarious sections of the South. The removal of vegetation and floatage is sometimes necessary whether oil or fish are used, and the cost of that work does not need consideration here, as it probably would not materially alter the final comparative cost of the two methods of control. It, therefore, is quite evident that as far as fish can be used, certainly the cost of the oil is saved by employing

fish, with the further advantage that mosquito control thereby obtained is usually not limited to the first season but may continue indefinitely.

Of course conditions exist where oil can be used to advantage and where fish are worthless. Fish can not be employed where a mere film of seepage exists or in hoof prints, and it frequently is not advantageous to use fish in very temporary pools, ditches, and swamps. Top minnows often do not work well in swiftly flowing creeks which, however, have quiet coves and pools. It seems advisable, therefore, because of the small cost and the more permanent results, to use fish under all conditions under which they will provide mosquito control and to apply the oil treatment only when fish can not be successfully used.

Drainage undoubtedly deserves first place among the measures of mosquito control because of its permanent character, but it is a recognized fact that all water deposits can not be eliminated. The cost of drainage is usually high and therefore in many localities prohibitive. It is not always possible to replace control by drainage with control by fish, as when the breeding areas consist of waters which will not support fish, but it is quite feasible to employ fish in all permanent standing waters which are not polluted or overpopulated with large predaceous fishes. Fish control is especially recommended for rural sections and for other localities when funds for the more expensive measures are not available. Certainly a great reduction in malaria can be obtained by the judicious distribution and protection of top minnows.

CONCLUSIONS.

1. *Gambusia affinis* is by far the most important natural enemy of the mosquito known to date. Throughout the malarious sections of the South it is abundant in nearly all permanent standing bodies of water and sluggish streams accessible to it. The use of *Gambusia affinis* in several southern States during antimalaria campaigns in 1920 resulted in a reduction in the cost of mosquito control and added much to the permanent nature of the work.

(a) This fish lives under a very wide range of conditions, and especially frequents the places which appear most favorable for the production of mosquitoes. There are some waters, mostly artificial, which are inaccessible to it, because of the presence of barriers, but if the fish are transplanted thereto a large reduction in mosquito production will result.

(b) *Gambusia affinis* seeks its food at the surface of the water and shows a distinct preference for live animals, but it also eats dead animal food and plants. Its sense of smell appears to be imperfectly



Fig. 21.—Section of ditch in abandoned rice field, Savannah, Ga., showing arrow-heads, pickerel weeds, and primrose willows in water. Photographed April 14.

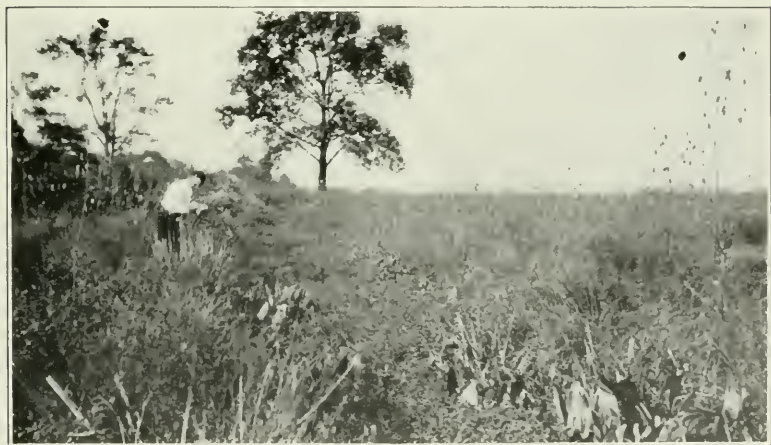


Fig. 22.—Same view as in above photograph. Note that ditch is now completely overgrown with vegetation. Top minnows were plentiful and excellent mosquito control prevailed. Photographed October 22.



Fig. 23.—Section of pond, Trinity, Tex., showing growth of rushes which do not prevent mosquito control with fish. This pond was used as a "hatchery." Photographed June 3.



Fig. 24.—Shallow section of pond, Huntsville, Tex., showing area in foreground completely overgrown with burweed. *Gambusia affinis* was abundant and complete mosquito control prevailed at the time when the inspection and photograph were made, June 4.



Fig. 25.—Slightly brackish swamp, Gulfport, Miss. Type of tall vegetation which rarely hinders mosquito control by fish. Minnows very abundant. Photographed April 27.



Fig. 26.—Section of pond at Jacksonville, Tex., showing shore vegetation. *Fundulus notatus* failed to provide mosquito control, and *Gambusia affinis* was added to secure complete control. Photographed June 1.



Fig. 27.—Section of a swamp, Gulfport, Miss., showing types of vegetation which usually do not protect mosquitoes from fish. Photographed April 27.



Fig. 28.—Section of same swamp as above, showing close view of tall wire grass. Rarely mosquito larvae find protection from fish among the root masses of the clumps of grass. Photographed April 27.

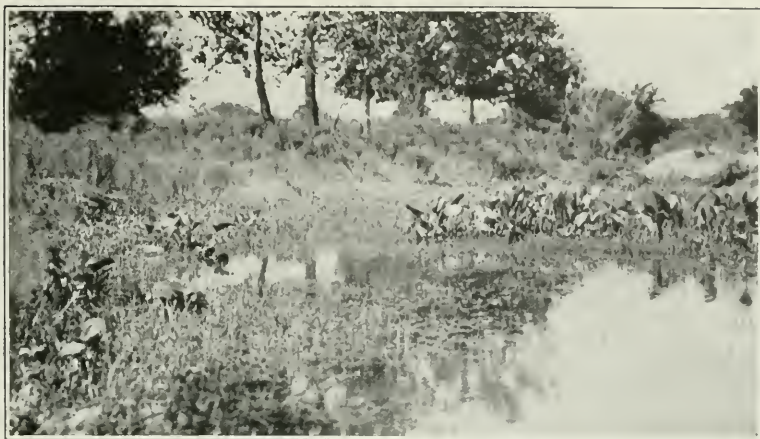


Fig. 29.—One of a chain of sink holes, Perry, Fla. Top minnows were abundant in most of them and many of them were under almost perfect mosquito control when inspected and photographed, August 11.

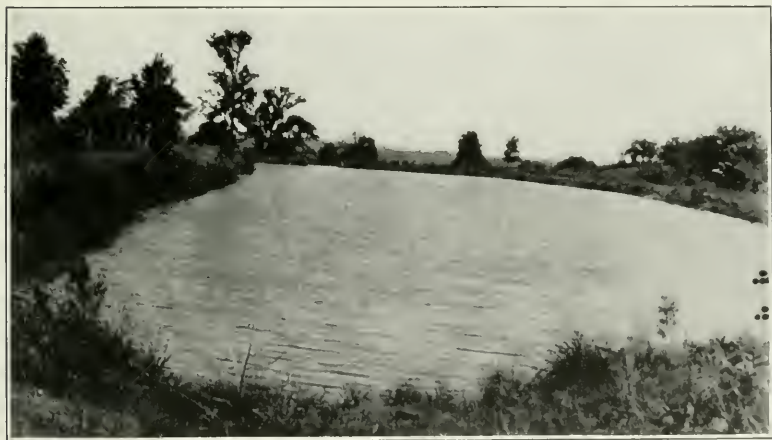


Fig. 30.—A type of pond which, because of size, depth, and freedom from vegetation, is subject to considerable wave action. Mosquitoes are able to breed only along the shores where they usually are easily controlled with fish.



Fig. 31.—Section of ditch, Savannah, Ga., showing inspector dipping for mosquito larvae among grass. This ditch was producing mosquitoes during October when 7,000 additional top minnows were introduced, resulting in complete mosquito control within about 10 days. Photographed October 30.



Fig. 32.—Section of same ditch as above, showing a growth of pickerel weeds and arrowheads. Photographed October 30.

developed and of no use to the fish in its search for food, but the sense of sight, by means of which the fish detects movements of its prey, is very important.

(c) Sexual maturity is reached at the age of about four months, and new broods consisting of a few to over two hundred are produced at intervals of from three to six weeks throughout the breeding season, which varies with the duration of warm weather.

2. *Molleinesia latipinna* inhabits brackish and fresh-water swamps and ditches along the coast from South Carolina to Mexico, and is frequently found in company with *Gambusia affinis*. It subsists on plants and is of no value as an eradicator of mosquito larvæ.

3. *Heterandria formosa* occurs in fresh-water swamps and ditches of the coastal plains from North Carolina to Florida. It produces new broods of young at short intervals and lives among vegetation. A limited range of experiments and observations indicates that it is a serious enemy of the immature mosquito.

4. Top minnows are the most effective agents known for the control of mosquito production in permanent ponds and lakes which can not be eliminated through drainage or which it is undesirable to eliminate. It has been found advantageous in many localities to use a particular body of water as a center of propagation of top minnows and a source for their distribution. Ponds in pastures and fields which supported aquatic vegetation or which were used by live stock gave the best results as *Gambusia* hatcheries.

5. Complete mosquito control does not always result from stocking a body of water with top minnows, because, in the first place, plants or floatage furnish refuge for the immature mosquito, or, secondly, the fish may not be sufficiently abundant to consume the available foods. It is very important to remove floating masses, or plants having slightly submerged leaves or possessing a dense network of roots near the surface of the water, as such plants are the chief sources of protection for the immature mosquito.

6. Fish control should be substituted for oil control wherever possible, because its results are much more lasting and it is generally less expensive.

RELATED PUBLICATIONS.

Available reprints and bulletins on malaria, issued by the Public Health Service, from which copies may be obtained without cost:

PUBLIC HEALTH BULLETIN.

88.—Malaria control: A report of demonstration studies conducted in urban and rural sections. By R. C. Derivaux, H. A. Taylor, and T. D. Haas.

REPRINTS FROM THE PUBLIC HEALTH REPORTS.

28.—Prevention and destruction of mosquitoes. By Joseph Goldberger. July 17, 1908, 11 pages.

217.—Mosquitoes and malaria: Report on a short trip in eastern North Carolina. By Charles Wardell Stiles. September 4, 1914.

260.—Control of malaria: Oiling as an antimosquito measure. By J. A. A. Le Prince. February 26, 1915.

328.—Demonstrations of malaria control. By R. H. von Ezdorf. March 10, 1916.

463.—Breeding of *Anopheles quadrimaculatus* in deep water and at a distance from shore. By H. R. Carter.

476.—Malaria control. Results obtained by a local community following anti-mosquito demonstration studies by the United States Public Health Service in cooperation with the International Health Board. Direction: J. E. Sparks, M. D., R. C. Derivaux, and H. A. Taylor, M. D.

500.—Some aspects of malaria control through mosquito eradication. By C. W. Metz.

527.—Fishes in relation to mosquito control in ponds. By Samuel F. Hildebrand.

552.—The malaria problem of the South. By H. R. Carter. August 22, 1919.

553.—The ultimate seasonal infection of malarial fever with the mosquito carrier as the indicator. By Bruce Mayne. August 29, 1919.

582.—Occurrence of malaria and anopheline mosquitoes in middle and southern California. By W. B. Herms.

595.—What can a community afford to pay to rid itself of malaria? By L. M. Fisher.

602.—Can the mosquito convey infection from a malaria patient undergoing treatment? Does sporogony affect mosquito life? By Bruce Mayne.



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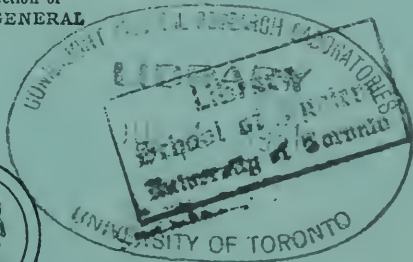
THE SECOND ANNUAL ANTIMALARIA CONFERENCE

OF

SANITARY ENGINEERS AND OTHERS ENGAGED
IN MALARIA FIELD INVESTIGATIONS
AND MOSQUITO CONTROL

HELD AT LOUISVILLE, KY.
NOVEMBER 16-17, 1920

Prepared by Direction of
THE SURGEON GENERAL



WASHINGTON
GOVERNMENT PRINTING OFFICE

1921

TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

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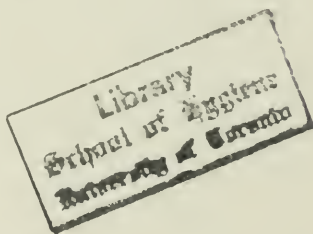
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Second Annual Conference of Sanitary Engineers and Other Officers of the Public Health Service Directing Antimalaria Campaigns.

TRANSACTIONS.

The second annual conference of sanitary engineers and other officers of the Public Health Service engaged in directing anti-malaria campaigns was held in Louisville, Ky., November 16-17, 1920. The following persons were present at the conference:

Surg. L. D. Fricks.

Special Experts M. A. Barber and W. A. Davis.

Senior Sanitary Engineer J. A. Le Prince.

Associate Sanitary Engineers L. M. Fisher, A. W. Fuchs, J. K. Hoskins.

Epidemiologist T. H. D. Griffiths.

Associate Sanitarian Bruce Mayne.

Acting Asst. Surg. C. P. Coogle.

Assistant Sanitary Engineers J. C. Carter, J. G. Foster, W. H. W. Komp, L. G. Lenert, H. N. Old, F. R. Shaw.

Sanitary Engineers, I. H. B., C. E. Buck, J. L. Clarke, E. H. Gage, L. G. Hastings, E. B. Johnson, E. H. Magoon, George Parker, William Ropes, H. W. Van Hovenberg.

Technical Assistant T. B. Hayne.

State Health Officers C. W. Garrison, J. A. Hayne, W. S. Leathers.

City Health Officer John Thames.

County Health Officer C. W. Shaw.

Members of State Health Departments M. Z. Blair, E. G. Eggert, A. P. Harrison, H. A. Kroeze, A. P. Miller, J. H. O'Neill, G. W. Simons, jr., E. L. Tilby, H. C. Woodfall.

Member of City Health Department W. G. Stromquist.

Visitors C. C. Bass, S. C. Beach, W. H. De Mott, R. C. Derivaux, J. A. Ferrell, S. F. Hildebrand, F. L. Hoffman, H. H. Howard, S. H. McCrory, Wickliffe Rose, D. L. Van Dine, R. A. Van Voast, P. H. Williams.

SECOND ANNUAL ANTIMALARIA CONFERENCE.

The meeting was called to order at 9.30 a. m., November 16, 1920, at the Engineers and Architects' Club, room 1410, Starks Building, Louisville, Ky., by Senior Sanitary Engineer J. A. Le Prince.

OPENING REMARKS OF MR. J. A. LE PRINCE.

There has been a slight change in our program. Mr. De Mott, of Nassau County, Long Island, will read the first paper.

Nassau County is doing very excellent county-wide work in malaria and mosquito control. The Nassau County Mosquito Extermination Commission kindly arranged for Mr. De Mott to come here this morning and talk to us.

Mr. De Mott has a large amount of data relating to his work, and the reason for getting him here primarily was that the time had arrived when we must begin county work and take up the problem of the rural districts.

Undoubtedly, we are going to get some information from him which will be of much value to us. The object of this meeting is to get information.

It should be stated that those who have not yet seen the malaria exhibit on the car "Anopheles" of the Cotton Belt Railway now at the Illinois Central Railroad depot by all means ought to see that exhibit. It is well worth while.

We came here to get all the information we can. We want essential facts. I was hoping that arrangements could be made so that we could extend our meeting until Thursday. It appears not to be possible, and therefore we must crowd our program and make use of all the time there is. Be brief, to the point, but do not omit important points.

We shall adjourn at 12 o'clock and then begin again at 1.30. Tomorrow we shall start at 8 o'clock, stop at 12, and then start again at 1 and continue until 5 o'clock. Mr. De Mott.

MR. DE MOTT. Mr. Chairman and gentlemen, before reading my paper, I wish to extend to you a hearty greeting on behalf of the Nassau County Mosquito Extermination Commission. They wish me to extend to you a vote of thanks for having invited me down here.

MOSQUITO-CONTROL ORGANIZATION IN NASSAU COUNTY, LONG ISLAND, N. Y.

WM. H. DE MOTT,

Chief Engineer, Nassau County Mosquito Extermination Commission.

The Nassau County Mosquito Extermination Commission was organized in June, 1916, with county-wide powers, directed by law to exterminate mosquitoes throughout the extent of Nassau County.

Our commission, as at present constituted, is composed of six members; James H. Dayton is secretary and William H. De Mott is chief engineer.

Our work is carried on under the general headings, "Salt marsh," "North and south shore upland"; therefore I will follow these capitulations.

SALT MARSH.

The commission started at once to drain the salt-marsh lands. The 800 acres of salt marsh scattered along the north shore of the county and the 19,000 acres stretched along the south shore, in a strip about 17 miles long and 3 miles wide, were breeding enough mosquitoes to invade the entire 300 square miles of the county in great hordes.

The work began at the New York City line and to date has been extended as far east as Wantagh. In 1917 the entire north shore salt marsh was drained. About 16,000 acres of the total acreage are now under control. Some 5,000,000 feet of ditching have been installed, at a total cost of \$100,390, draining an area approximately 14 miles long.

Great results have been obtained this year on the salt marsh where ditches have been installed. A marked decrease of salt-marsh mosquitoes has been found from Inwood to Merrick, a distance of 11 miles on the south shore, and no salt-marsh mosquitoes on the north shore from Cold Spring Harbor to Great Neck, a distance of 17 miles. In previous years they were very annoying in these localities.

SALT-MARSH MAINTENANCE AND PATROL.

Contrary to the plan generally followed, we have no big spring clean-up on the marsh. The work is carried on by a district inspector, 4 inspectors, and 18 laborers. The district is divided as evenly as possible into four sections. In each section, except one, there are a little over 1,000,000 feet of ditches to be maintained. Each section is in charge of an inspector with a labor crew of from four to six laborers. The inspector is held responsible for the condition of his section.

The commission has three motor boats and one motor truck for salt-marsh transportation.

The cost of salt marsh maintenance and patrol from April to October this year was \$10,471.59.

NORTH AND SOUTH SHORE UPLAND.

For the purpose of mosquito control on the upland, let us first make a study of malaria. From whatever angle it is viewed, the

malaria problem must appeal to any thoughtful person as one of the chief questions in any community where it is prevalent. Health must be considered as one of the main aspects of any place.

It is important simply from the standpoint of health. Physical preparedness underlies all other preparedness. Malaria is a subtle disease. It constantly lowers the efficiency of the patient, it de-

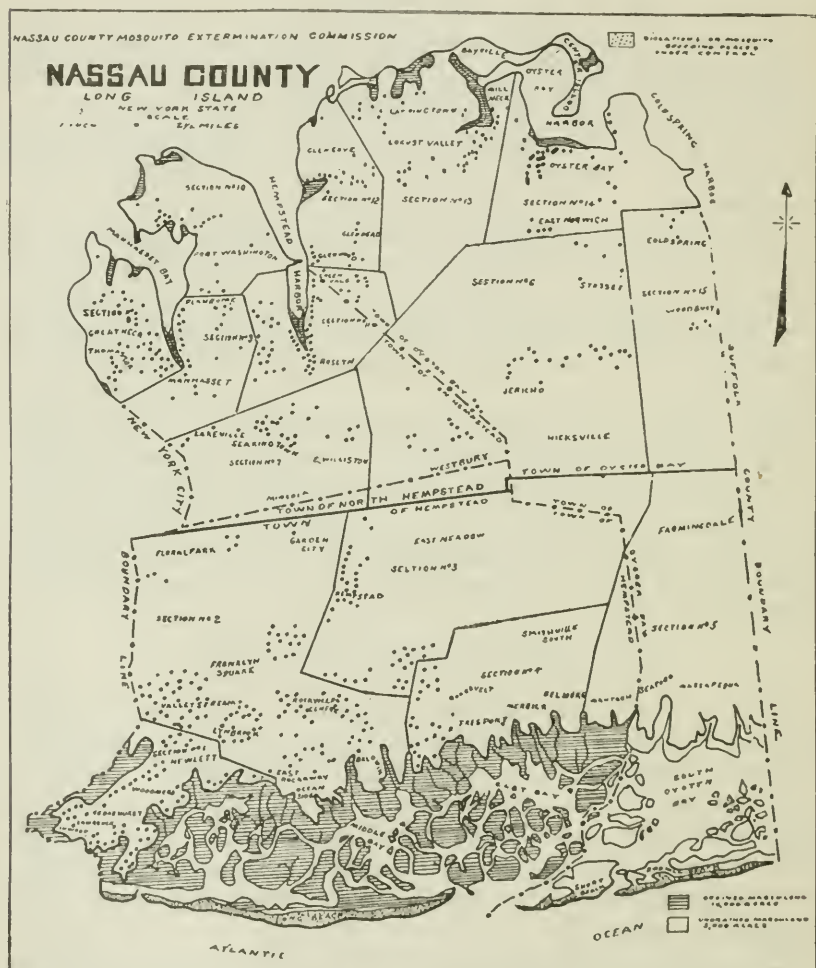


FIG. 1.

creases the resisting power of the system to throw off other diseases, it enters frequently into complications with other diseases, and, at times, makes diagnosis uncertain.

Malaria can be prevented. How? By exterminating the Anophles mosquitoes, and keeping their breeding places under control; by organizing a system that will enable the men in charge of the

inspection and oiling to get over the territory often. The chief engineer must be in constant touch with his men, cooperating with his force at all times, and with but one object in view—mosquito extermination and malaria control.

HISTORY OF MALARIA CAMPAIGN.

Shortly after scientists proved the *Anopheles* mosquito to be the only transmitter of malaria to man, mosquito extermination on the north shore of Nassau County was agitated.

In 1910 the Matinecock Neighborhood Association of Locust Valley carried on a \$6,000 campaign, and for the next four years maintained the work installed. Following the pioneer work of this association, the people of Port Washington and Glen Cove expended some \$2,000 in 1914 on oiling, ditching, and maintenance. The work was continued in 1915 by the Great Neck Association, which did approximately \$1,000 worth of work.

So the fight against malaria was carried on in the county for several years by individuals, societies, welfare organizations, and communities until in 1916 the Nassau County Mosquito Extermination Commission became operative, and took over the work of the local organizations.

MALARIA CONDITIONS.

It might be well to look briefly at the record of the upland work done by the commission in the past four years, so that some idea may be gleaned of the effort put forth to obtain the results mentioned hereafter.

As the commission was not organized until June, 1916, the malaria work that year consisted chiefly of maintenance of the work previously installed and location of breeding places.

In 1917 the commission maintained an upland labor crew, consisting of 1 foreman, 18 laborers, and 10 inspectors, on the north shore. The district included the territory from Great Neck east to Cold Spring Harbor on the north and from Floral Park east to Mineola, thence along the old country road to Plainview on the south, covering an area of approximately 135 square miles. This section of the county was being inspected and patrolled by 10 inspectors, whose only means of transportation were bicycles. The oil was transported by horse and wagon, and sprinkling cans were used for pouring the oil on the surface of the water of the numerous violations or breeding places.

This was a slow and expensive method, accomplishing very little, and necessitating years of hard work to obtain the results that we have obtained in three years under the present system.

It was not until 1918 that the organization of the upland work was satisfactorily established. In 1918 I was appointed chief engineer. Having been in the employ of the commission as a district inspector since it was organized, I was in a position to see that in order to exterminate the *Anopheles* mosquitoes and get malaria under control a new system of inspecting and oiling must be installed. The only solution, where the territory was so large, was the installation of automobiles.

AUTOMOBILE TRANSPORTATION.

I brought the question of transportation before the commissioners, recommending the use of automobiles for inspecting and oiling of upland violations on the north and south shores. This was approved by the commission, and four automobiles were purchased at once. The cars were equipped with a small box body, large enough to carry one barrel of oil, two spray pumps, and two 4-gallon oil tanks.

Instead of employing a man to do inspection and another to do oiling, I combined the work and had the inspector do the oiling, too.

I am very much in favor of teamwork; two inspectors work together better than one man alone. This is the method: One automobile, two men, one barrel of oil, two small oil tanks with pumps, hose, and spraying nozzle attached. Inspections are made and when breeding is found the breeding place is oiled and the larvæ killed immediately. Our motto is, "Kill it while it is young."

COMPARISON OF OLD AND NEW SYSTEMS.

Season of 1917, transportation—bicycles, horse and wagon.

Number of inspectors employed.....	10
Total number of inspections made.....	1, 329
Total number of violations.....	206
Total number of times breeding killed.....	330
Total number of gallons of oil used.....	2, 600
Number of malaria cases reported in four communities.....	51
Cost per acre (on north shore) (cents).....	14

Inspections made every 12 days.

Season of 1918, transportation—automobiles.

Number of inspectors employed.....	5
Total number of inspections made.....	5, 788
Total number of violations.....	355
Total number of times breeding killed.....	595
Total number of gallons of oil used.....	3, 308
Number of malaria cases reported in 4 communities.....	0
Number of malaria cases reported in entire county.....	5
Cost per acre (on north shore) (cents).....	8

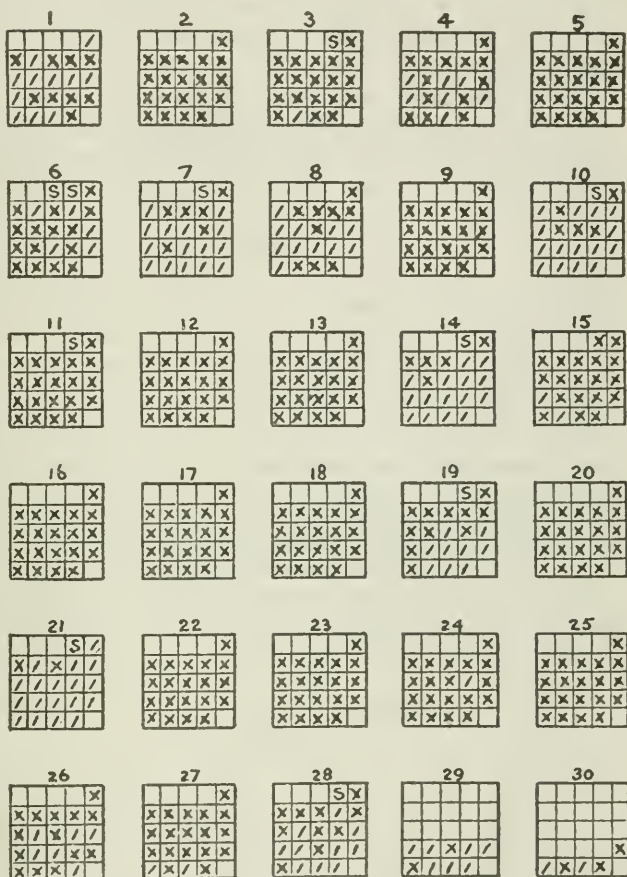
Inspections made every 8 days.

CHECKING CHART SYSTEM.

In order to keep a complete record of the inspections made, breeding found and exterminated in the upland violations, a checking chart was installed. The north and south shore upland was divided into two districts, and the districts were divided into sections. In each section there are from 12 to 135 ponds, swamps, pools, streams, and wet areas, which we call violations or breeding places. In the county there are 15 sections, 5 on the south shore and 10 on the north shore.

CONSTRUCTION
OF INSPECTION
CHART.

The large squares on the chart indicate the violation, and the small squares show the number of times the violation was inspected. The squares marked with a black



*Inspected marked X.
Inspected-oiled marked I.
Spring oiling marked S.*

FIG. 2.—Nassau County Mosquito Extermination Commission.
Sample chart showing violations inspected or inspected-oiled.
North shore, season 1920, section No. 10, Port Washington.

cross show inspections but no breeding found. Squares marked with a diagonal line show inspections, breeding found, the violation oiled, and the larvæ killed. We have a full set of these charts covering the seasons' work on the north shore from 1917 to 1920.

PERSONNEL.

During the year 1918 two upland labor crews, consisting of 2 foremen and 10 laborers, were employed to do the maintenance work on the north and south shores. In 1919 the same number of inspectors and laborers was employed on the upland districts. The malaria was kept well under control; only three cases were reported in the entire county.

The *Anopheles* mosquitoes have been fought to a standstill. Although they were found breeding in 24 communities, the commission made a record this year. The field force worked with untiring efforts to keep malaria out of the county.

Summary of upland work, season of 1920.

Total number of violations.....	652
Total number of inspections.....	12,595
Total number of times breeding killed.....	1,877
Total number of gallons of oil used.....	16,443
Total footage new ditches installed.....	28,864
Total footage old ditches cleaned.....	663,449
Total footage old ditches recleaned.....	12,425
Total number ponds lowered.....	34
Total number swamps drained.....	1
Total footage pond edges trimmed and cleaned.....	5,000
Territory under control (square miles).....	200
Cost per acre (with high cost of labor) (cents).....	12
Number of cases of malaria in entire county.....	0

Inspection made every 6 days.

District No. 3, breeding summary, season 1920.

Violation.	Total number times breeding.	Culex.		Anopheles.		Aedes.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Ponds.....	974	316	32.4	595	61.2	63	6.4
Swamps.....	355	231	65.0	26	7.5	98	27.5
Ditches.....	143	91	63.8	31	21.8	21	14.4
Salt marsh.....	1					1	100.0
Gutters.....	11	9	81.8	5	45.5		
Streams.....	29	11	37.8	17	58.4	1	3.4
Pools.....	178	142	79.5	14	8.0	22	12.5
Catch basins.....	3	3	100.0				
Cisterns.....	2	2	100.0				
Lily basins.....	48	16	33.1	29	60.5	3	6.4
Cesspools.....	15	15	100.0				
Barrels.....	11	8	72.7			3	27.3
Culverts.....	7	5	70.0	2	30.0		
Springs.....							
Wet areas.....	42	30	71.5	5	12.0	7	16.5
Total.....	1,822	879	48.2	724	39.8	219	12.0

COST OF OPERATIONS.

Following is the cost of operations from April to September 30:

Chief engineer, secretary, and clerk.....	\$2,526.00
2 district inspectors.....	1,663.00
11 inspectors.....	7,287.50
2 foremen.....	1,200.00
24 laborers, salt marsh and upland.....	11,834.00
Total.....	24,510.50

Motor transportation.

Repair parts, 8 cars, 3 boats, 1 motor cycle.....	375.57
Gasoline, 8 cars, 3 boats, 1 motor cycle.....	1,181.34
Lubricating oil, 8 cars, 3 boats, 1 motor cycle.....	64.50
1 machinist.....	685.00
Total.....	2,306.41
Cost per vehicle per month.....	32.04
Cost per vehicle per working-day.....	1.24

DOCTORS' MALARIA REPORTS.

In 1916 we sent reports to the physicians in four north-shore communities, requesting them to report to us any cases of malaria which had occurred. In 1917 we sent reports to all north-shore communities, and in 1918, 1919, and 1920 to all physicians throughout the entire county. Their response has been general and gratifying, and their cooperation is highly appreciated.

The following table gives a comparative summary of malaria conditions throughout the county:

	Annually to 1916.	1916	1917	1918	1919	1920
Number of communities reporting.....	4	4	7	19	18	15
Number of doctors receiving reports.....		16	41	111	99	82
Number of doctors reporting.....		14	23	35	46	28
Number of reports received.....		82	133	79	289	254
Number of cases:						
North shore.....	475	56	51	5	2	0
South shore.....					1	0
Total for county.....	475	56	51	5	3	0

It is convincing proof of the success of the work that in 1920 reports from all localities in the county reveal no cases of malaria as compared with 475 annually from only four communities previous to 1916. The number of cases reported in the last three years—5 in 1918, 3 in 1919, and none in 1920—shows that the work carried on by the commission has effected an absolute control of malaria conditions which a few years ago were alarming.

One big factor of our success is our motor transportation. It might be well to state at this time that we have a fully equipped repair shop, and one expert machinist who keeps the cars and boats in perfect running order. The commission has purchased more cars, and now owns 8 cars, 3 boats, and 1 motor cycle. Unquestionably, motor transportation has given Nassau County mosquito extermination.

DISCUSSION.

Mr. LE PRINCE. We have all enjoyed your paper very much, Mr. De Mott. I hope enough questions will be asked so that we will get the full value out of this paper. The subject is now open for discussion. I will set the ball rolling. I want to ask Mr. De Mott whether or not there was any difficulty in convincing the commissioners of the need of transportation, and also ask what arrangements were made regarding funds for each year. Do you have any difficulty in obtaining the funds, or is that arranged for? Does it take up any of your time?

Mr. DE MOTT. In regard to the automobiles that were procured for transportation, the commissioners opposed them very strongly until I showed them that in order to get results we must get over the territory quickly. We have covered 17 miles of the north shore and the same on the south shore. It was impossible for the men to get over that territory on wheels. After explaining it, the commissioners readily understood that we must travel fast if we were to have results.

With reference to the money in Nassau County, we are allowed three-eighths of a mill to the dollar of assessed valuation. In other words, on \$1,000 of assessed valuation we receive $37\frac{1}{2}$ cents for mosquito extermination. During the year of 1916 we received \$40,000; 1917, \$40,000; 1918, \$48,000; 1919, \$54,000; 1920, \$54,000. Next year our appropriation will be more, because the assessed valuation of the county has increased. It will be approximately \$74,000. We have a population of 130,000.

Mr. LE PRINCE. I want to ask how you brought that state of affairs about; in a few words, the inside history of the getting that law passed, if it is a law?

Mr. DE MOTT. Previous to the organization of the commission, this work was carried on by private organizations. In order to get results, it must become a county-wide proposition. All that was necessary to get this bill through the legislature was a petition signed by 200 taxpayers of the county. The work on the north shore, which is the richest section of Nassau County, was being handled by a number of influential men who were ready and willing to sign this petition. As soon as the petition had been properly signed, it was presented to

the assemblyman of Nassau County, who presented the bill to the legislature.

Dr. FRICKS. I have no question to ask Mr. De Mott, but I certainly was delighted to hear his paper. I wish some of the doubting Thomases that we have all encountered with respect to drainage on a county-wide basis could have heard Mr. De Mott's paper.

I have been of the opinion since my connection with the work that if we are going to carry it on permanently and extend it properly, malaria control here in the South must be on a county-wide basis. I believe the county is the logical health unit in the southern States, and that unless we put our malaria control on that basis we have no assurance of its permanency. I feel that it is up to you engineers to profit by the paper this morning and evolve some logical way of doing in the South what they have done in New York.

Mr. DE MOTT. I want to say for the benefit of the members, do not think for one minute that we don't have criticism. We do, from one end of the county to the other. The hay farmer criticizes us because we have ruined his hay meadow. This is not true. When you drain the salt marshes you increase the yield of hay 75 per cent, and the only thing he loses is the place where the sod lies on both sides of the ditch. They have criticized us for four years, and we have stood their criticism knowing that they did not know what they were talking about, and we know what we are doing. Regardless of the cost, regardless of the criticism, we know that we are doing a work for the benefit of mankind. Until we educate the people, we will never get complete results; but never mind, whether you educate them or not, fight the thing from start to finish, regardless of criticism. A lady said to me, "We are not bothered with mosquitoes, nor do we have malaria." She wanted to get an officer and have our men arrested because they walked on her property in order to oil a pond which was breeding malaria mosquitoes. If we had taken our men off that place, we would have accomplished nothing. Mosquitoes would have gotten on the wing, malaria would have been prevalent in that village as it had been once before. In 1916 there were 48 cases in that village; to-day, none, just because we know what we are doing and they don't know what they are talking about. [Applause.]

Mr. O'NEILL. I would like to ask Mr. De Mott the character of the population of Nassau County; that is, is it mainly rural or does it consist of small towns or one large town.

Mr. DE MOTT. We have 19 incorporated villages, and in those incorporated villages there are from five to nearly ten thousand people.

The rest are small towns, rural districts. With one or two exceptions the villages do not have sewerage. They have cesspools which are our main trouble. The people think because the cesspool cover

has a hole in it, it must remain there. However, we are not doing house-to-house work at all. Mosquito extermination is built up the same as a house—you must place the foundation before you put the roof on, so the first step taken was the drainage of the salt marshes, next the control of upland violations, and the third step will be the house-to-house work.

The people do not fear the *Anopheles* or other species of fresh-water mosquitoes—but the *Culex*. They admit there are no daylight mosquitoes at all, but at night they have them. We have interviewed some of the people and induced them to clean up their back yards and put the cesspool cover in proper condition. By the time we get to the house-to-house work, we are going to have the people educated so well that it is going to cost Nassau County very little for that part of the work.

Mr. CLARKE. I would like to ask the number of towns in the territory and the density of population.

Mr. DE MOTT. Sixty-eight villages with a population of approximately 130,000.

Mr. LE PRINCE. I would like to correct an impression that may have been made on some of those here. You may think that the people of Long Island are very easy to convince. A matter of 5 miles away from where Mr. De Mott is working there is a community of people with plenty of money, but still more mosquitoes than they have had for years; and people go to that community and are driven away year after year. The local population there is not convinced yet. It is not in the county in which Mr. DeMott is working. He has the same difficulties that you have in the areas in the different States you are working in.

Mr. FUCHS. Mr. De Mott, how do you plan your expenditure? Do you estimate the cost for oiling and inspection and spend the remainder of your appropriation for permanent drainage?

Mr. DE MOTT. Yes. Most of our permanent drainage work is on the salt marshes.

We have some permanent drainage on the upland. The cost of the permanent drainage in 1919 on the north shore was \$176.38. Most of our violations are ponds and marshy, swamp areas, and there has to be a maintenance of these. A large number of the ponds are in yards, and are kept under control by oiling. One pond we blasted during the year 1920 and entirely eliminated it.

We found that on the north shore of Long Island there is a stratum of clay ranging from 5 to 18 feet in depth. By blasting we can put a hole in the bottom of the pond and drain the water entirely out.

Mr. PARKER. Is the money that is appropriated by the county for this work used in the incorporated limits of a town? In other

words, is the town worked in conjunction with the rest of the county without doing anything in the way of raising money for local work?

MR. DE MOTT. The money that is raised for mosquito extermination for Nassau County is for Nassau County, from the north shore to the south shore, from the Sound to the ocean. We are fighting malaria for humanity; it doesn't make any difference whether it is a negro or who it may be.

MR. HOSKINS. Has fish control been attempted in ponds, especially on those estates where the beauty of the pond is an asset to the property?

MR. DE MOTT. Fish control was attempted in several of the ponds. We find that the fish will not eat all of the wrigglers, and a great many of the pupæ are left, and get on the wing.

MR. LE PRINCE. I would like to ask a question. Did you find that the public was anticipating the visits of the inspectors and actually cooperating by doing the work that you would otherwise have to do?

MR. DE MOTT. Yes. We make it a special work of the inspectors to get in touch with the owners, or the superintendent on the property. We generally talk with the superintendent in charge, who cooperates with us. Sometimes they do the work themselves; sometimes they go with us and see how we do it. On the north shore, where we have our malaria problem, we have found that the superintendents on the different estates have been willing to cooperate with us in every respect.

MR. OLD. I would like to ask, Mr. De Mott, what kind of oil you use?

MR. DE MOTT. We use No. 34 distillate fuel oil.

MR. OLD. Does that spread among the vines that you speak of in the water?

MR. DE MOTT. Yes. We tried kerosene, and found that it would kill the *Anopheles* but would not kill the *Aedes*. One of our inspectors said to me, "I think the *Aedes* larvæ are getting fat on kerosene." We took the dripping of oil from the cars and mixed it with kerosene and that has a kick. I wish I could get that kind of oil all of the time.

Breeding of *Anopheles* was higher this year on the north shore than it has been for two years. Thirty-nine and eight-tenths per cent of the breeding found was *Anopheles*. In some districts the *Anopheles* were as high as 100 per cent. Most of them were *quadrimaculatus*; we had very few *punctipennis*.

DR. GRIFFITHS. Mr. De Mott, is *quadrimaculatus* found in brackish water?

MR. DE MOTT. No; not in brackish water; mostly in brooks and ponds.

DR. GRIFFITHS. You did encounter *crucians*?

MR. DE MOTT. Yes; but very few.

MR. KOMP. What kind of spray pump was used?

Mr. DE MOTT. The spray pump is the Deming sprayer. It has a 4-gallon container and a foot pump. We used a 4-foot hose and a Bordeaux sprayer. The knapsack spray we received, but the men refused to use them, because the oil got on their clothes. I procured the Deming sprayers and they were very successful.

Mr. KOMP. Do you know what species of fish were used?

Mr. DE MOTT. No; I don't know what species were used. I am not much interested in fish control, to tell you the truth.

Mr. HILDEBRAND. I wish to remark that Mr. De Mott is handicapped in fish control because he does not have the species of fish that we have in the South and probably that is the reason he has not had as much success as we have had in the South. I know from our northern representative, Dr. Moore, of Pennsylvania University, that fish control has not met with the success there that we have had in the South.

Mr. VAN HOVENBERG. Mr. Chairman, I would like to speak about something I saw in California this summer, in case the question of spray pumps is not brought up again this morning. We have all been troubled with the complaints of oilers, due to the spilling of oil from spray pumps upon their backs. The California spray pumps had a metal strip about an inch and a half wide soldered around the whole top of the can, so that any oil escaping from the valve may be caught on the inside of the rim. This will avoid absolutely the spilling of the oil down the carrier's back.

Mr. PARKER. Mr. De Mott said, I believe, that they were not paying very much attention to *Culex*. I would like to ask whether containers affect *Anopheles* production?

Mr. DE MOTT. We found that the *Anopheles* breed in the ponds, brooks, and streams. We have found *Anopheles* in barrels, that is all. We do not say that we are not killing the *Culex*. We have a great many stagnant ponds where *Culex* breed, but that does not include the house-to-house work.

Dr. HARRISON. Mr. Chairman, I should like to ask Mr. De Mott just what connection the State board of health has with the work in New York, and how many counties are carrying on mosquito-control work in the State at the present time?

Mr. DE MOTT. Nassau is the only county in the State that is doing mosquito extermination outside of Greater New York. I believe that Suffolk County is going to put through a bill in the legislature this winter to have mosquito extermination instituted.

We work under the direction of the State board of health. My proposed annual budget is sent to the State board of health, and it has to be approved by Mr. Horton, the chief engineer. He can approve or disapprove of the amount of money that has been raised,

but has been very courteous. The State board of health does not assist in obtaining appropriations.

Dr. HARRISON. Just one other question. You stated your appropriation for the past two years was fifty-four thousand. Now, do you think that there is a material decrease in the upkeep of your work, and what are your plans for continuing? Is it going to cost that much indefinitely?

Mr. DE MOTT. No. The largest amount of our appropriation each year has been used in the installation of ditching on the salt marshes. We have spent each year approximately fifteen to sixteen thousand dollars for drainage work on marsh land alone. We have about 2,000,000 linear feet more to install and then these salt marsh areas will be drained. After the drainage is completed it will cost at least \$14,000 a year to maintain it, but the cost of installation will cease, and the amount of appropriation will be less, because we use a smaller amount of money on the upland than we do on the salt marsh. I should judge we will be able to maintain the work in Nassau County, probably in 1923 or 1924, for \$34,000 a year. I don't feel like stating any less amount than that for the work.

Mr. SHAW. Have you experienced any difficulty or objection on the part of the people because of funds being used more in one locality than in another?

Mr. DE MOTT. We wanted the people of Glen Cove City to blast a pond. Immediately they wanted to know if the money raised through taxation did not pay for mosquito extermination in Glen Cove City, and if they received their pro rata share of the work. I said, "Gentlemen, we are doing mosquito extermination in Nassau County wherever it is. If you have 50 violations we will take care of them; if you have only 1 violation we will take care of that. You are getting your pro rata share. We are taking care of the pond by oiling; if it was blasted it would be entirely eliminated."

Mr. DAVIS. I want to get straightened out on the *Culex* proposition. You say you do not bother with the house-to-house work, the containers breeding *Culex*?

Mr. DE MOTT. No. We will not get rid of the *Culex* until we take up the house-to-house work. We are fighting the salt-marsh and upland fresh-water mosquitoes. Don't think, gentlemen, that we don't have mosquitoes in Nassau County. We do, but most of them are *Culex pipiens*.

Mr. LE PRINCE. Anybody here who is interested—and you should all be interested—in the New Jersey work ought to get a publication prepared by Dr. T. J. Headlee, State Entomologist of New Jersey, New Brunswick, N. J. It is well worth reading; everybody here ought to have it, particularly the State health department officials.

As we are pressed for time, there will be no further discussion of this paper, but for the benefit of those who were not here in the opening part I would like to state that there was as much valuable information given in that paper and in the early part of the discussion as there was real amusement in the latter part of the discussion, and everybody most certainly should read it. It brings to you what the State health departments are about to undertake, or will undertake within the next few years—the control of malaria in the rural districts; the big project. There is no reason at all why our Southern States can not undertake county-wide projects as has been done in the North, and the general manner of procedure has been laid down in Nassau County and in various counties, five of them, in the State of New Jersey.

I think we all owe thanks to the Nassau County Mosquito Extermination Commission for sending Mr. De Mott to give us the valuable data he has given us this morning. [Applause.]

(The conference gave the Nassau County Mosquito Extermination Commission a rising vote of thanks.)

Mr. LE PRINCE. The next paper this morning will be "Service policy and administrative methods in malaria-control investigations," by Dr. FRICKS.

Dr. FRICKS. I am pleased that the chairman has arranged for my paper to follow Mr. De Mott's. He has just told us how mosquito control is actually being conducted on an extensive scale in New York, and I believe his experience will enlighten us as to the probable lines along which malaria control in the South will be developed in the future.

SERVICE POLICY AND ADMINISTRATIVE METHODS IN MALARIA-CONTROL INVESTIGATIONS.

L. D. FRICKS,

Surgeon, United States Public Health Service.

"Not a day passes over the earth but men and women of no note do great deeds, speak great words, and suffer noble sorrows. Of these obscure heroes, philosophers, and martyrs, the greater part will never be known until that hour when many that were great shall be small and the small great." In this strain Charles Reade deplors the inadequacy of historical records. This stricture applies with great truth to at least one phase of malaria control. How much the early settlers of the United States and their descendants unconsciously contributed to the control of malaria through their desire for increased crops and better living conditions can never be known. How much the better class of rural families are now contributing to the same end for exactly the same reasons, without any thought of the mosquito theory of malaria transmission, can only be surmised. Unquestionably, however, their contribution is great. But except for a few sporadic efforts, the active measures taken for the control of malaria in the United States are of such recent date as to be commonly known to everyone interested in public health work. The first chapter in the control of this disease in the United States was written in great part by officials of the Public Health Service under the guidance of Dr. H. R. Carter, Dr. R. H. von Ezdorf, and Senior Sanitary Engineer J. A. Le Prince.

It covered the period between 1913 and 1918. In the beginning less than \$3,000 was allotted for malaria investigations from funds appropriated for the field investigation of public health. These investigations consisted of (1) collection of information concerning malaria prevalence and distribution, (2) demonstrations of malaria control, and (3) educational campaigns. The popular demand for demonstrations in malaria control grew so rapidly that additional funds were required each year in order to partly meet the demand. However, the allotment for malaria investigations for any one year previous to 1918 did not exceed \$20,000. By the end of 1917 it had been clearly demonstrated that malaria could be controlled, in urban communities, at least, through drainage and oiling; and that in communities where malaria was prevalent, the cost of such control was

considerably less than the annual tax from malarial diseases. The first chapter in malaria control investigations in the United States was closed at the end of 1917—malaria control in certain localities had been clearly proven possible and generally profitable and therefore this aspect of malaria investigation may fairly be considered as successfully terminated.

The second chapter in the Public Health Service control of malaria was of an entirely different character—it had to do with the protection of the health of our soldiers under war conditions. It consisted of malaria control and not malaria-control investigations. An appropriation of \$500,000 was made by Congress for "protecting health of the military forces." A sum greater than this amount was secured from local communities around the different cantonments, and these funds, amounting to more than \$1,000,000, were spent in 27 extra-cantonment zones for the protection of the health of the soldiers and civilian populations. By far the greater part of this fund was spent around cantonments located in the South, and at these places the greatest expenditure was for malaria control. An emergency had to be met; time was precious, and necessarily under this pressure due economy could not always be practiced. However, those of us who had seen the deplorable insanitary conditions existing around southern military camps during the Spanish-American War and the resulting waste of human lives can but feel that the expenditures as made for the protection of the health of our soldiers in the World War were amply justified. This was a chapter dealing with malaria control alone, except in so far as general deductions may be made for future control work, and should not be taken as a standard of service activities and service cooperation for malaria-control investigations of the future.

The third chapter of service malaria-control investigations begins with the discontinuation of extra-cantonment activities by the Public Health Service in 1919. The same general policy in malaria investigations as had been conducted before the war was resumed, but upon a more extensive scale. An allotment of \$80,000 was made from the appropriation "Field investigations of public health for the year 1919." Because of the influence which radiated from the extra-cantonment areas, it was deemed wise at this time to enter into a cooperative agreement with 10 different State health authorities and the International Health Board in a widespread investigation of malaria control in urban communities and the possibilities of its extension therefrom and incorporation as a part of the regular health program of State and local health authorities. This cooperative agreement was not completed until the season of 1919 was well advanced, but the personnel of the field force was selected and many preliminary malaria surveys were made before the end of the year.

These cooperative malaria-control investigations have now been in operation throughout one season, and we are here to discuss service policy and administrative methods in carrying on this work. In beginning this discussion it will probably be well to quote the memorandum prepared in the bureau outlining the reasons for and plan of conducting cooperative malaria investigations and control:

In order to promote the control of malaria in the United States and to accelerate the conduct of this work by the properly constituted authorities, the following plan of cooperation between State and local health authorities, the International Health Board, and the Federal Government, through the Public Health Service is proposed:

1. The Public Health Service will, on the approval of the plan and the request of the State board of health officer, assign to States officers trained in malaria-control measures to make surveys, prepare estimates for malaria-control work, and furnish expert supervision required to carry on such work.

2. The State and local health authorities will jointly provide the necessary funds to cover the cost of antimosquito control measures, and indicate the places where such control measures are to be carried on.

3. In instances where the State and local health authorities are unable to immediately provide all funds necessary to carry on the malaria-control measures indicated, the International Health Board will provide a certain percentage according to budgets approved by the parties to the cooperative agreement.

4. It is expected that, as soon as the value of the work is more widely demonstrated and the ultimate cooperative basis aimed at is attained, the antimalaria work will be carried on as a permanent feature of the cooperative health work of the governmental agencies, Federal, State, and local, without assistance from private agencies.

In considering service policy in relation to malaria-control investigation, it is necessary that we keep clearly in mind three fundamental facts: (1) The allotment under which we are working is made from the appropriation "Field investigations of public health"; (2) the feasibility of malaria control in urban communities by means of drainage and oiling has long since been demonstrated and therefore is not *per se* a proper subject for further investigation; (3) the allotment under which we are working is made for the investigation of all malaria problems affecting the public health and not for any one particular aspect of the problem. Since the malaria allotment is made for investigational purposes, it would clearly be illegal to spend this money for malaria control alone no matter how great the need of control might be in any community and it would just as certainly be unjustifiable to spend these funds in the investigation of malaria problems which have already been solved. Legislation has been proposed from time to time and has met with considerable support in both Houses of Congress which would enable the Public Health Service to expand its health activities and enter into an extensive cooperative program for the control of human diseases with the different State and local health authorities, similar to the Gov-

ernmental cooperative program of disease control among domestic animals, but up to the present time Congress has not seen fit to authorize such governmental activities nor appropriate funds for such an extensive health campaign.

Demonstrations in malaria control were early recognized as one of the most fruitful fields of investigation, and some may consider that there is still a legitimate field for malaria-control demonstrations, such as were so successfully conducted by the service from 1913 to 1917. No doubt in certain communities presenting peculiar local problems, demonstrations would be perfectly justifiable in order to investigate the peculiar local problem, but any widespread plan of malaria-control demonstrations might be easily extended to include every community in the United States in which malaria is a health problem without increasing our present knowledge of malaria control in the least.

In my judgment the service policy in malaria-control investigations is clearly indicated in the memorandum prepared in the Surgeon General's Office at the inauguration of our program for cooperative malaria work. This policy is contained in the first sentence, which reads as follows: "In order to promote the control of malaria and to accelerate the conduct of this work by the properly constituted authorities," etc. It is perfectly clear in my mind that the investigation of these two subjects is the only justification we have for the expenditure of Government funds under the cooperative malaria-control program.

Every effort has been made from field headquarters to impress upon the field directors the importance of this policy and necessity for making an investigation out of the control measures which are under their direction. It is easily understood how a field director might become so enthused over the success of the drainage and oiling operations immediately under his direction as to lose sight of the ultimate object sought in these control investigations. It is also granted that unless the control work is properly done we can have no hope of promoting or accelerating local effort in malaria control; but unless the field director goes further than a successful demonstration and employs every effort in investigating measures which promise the continuation and expansion of the work under his direction by the State and local health authorities and its grafting on to the regular health program of the community he will have fallen far short of what is expected of him and will have wasted time and misspent money which was appropriated for an entirely different purpose.

Another matter which we should consider briefly is that our allotment is made for the investigation of all malaria problems and the field being so large and the funds so small, only the most im-

portant and most pressing problems can be investigated at any one time. The importance of these problems may vary from time to time. Some will be solved, others altered, but it has been the policy of the service to undertake first the investigation of those problems which seem to promise the greatest practical results in decreasing malaria sickness and at the same time to carry on what we have termed purely scientific investigations. The line of separation between the two classes of investigations is neither fixed nor very definite; but under the first head may be grouped demonstrations and investigations of malaria control, and under the second all other laboratory and field investigations.

As stated above, the grouping is arbitrary, but it seems natural in many ways. It is frequently difficult to determine just how much of an inadequate allotment should be spent under the first head and how much under the second. During the first three months of the present fiscal year approximately \$15,000 was spent for the investigation of malaria control by the service and approximately \$6,000 for the investigation of all other malaria problems. It may be questioned whether this is the wisest division possible of our expenditure under the allotment.

In the beginning service-malaria investigations were conducted with a divisional headquarters first in the marine hospital, Mobile, Ala., then from the marine hospital at New Orleans. This arrangement was made both for the convenience of the medical officer in charge and for reasons of economy. During the war emergency the administrative duties at field headquarters were reduced to a minimum and the office was practically left in charge of a competent clerk. The actual direction of malaria-control operations in the extra-cantonment zones was conducted in person in the field by Dr. Carter, Dr. Derivaux, and Mr. Le Prince. In 1919 the malaria field headquarters was moved from New Orleans to Memphis, Tenn., and separated from any other service station. The increased allotment for malaria investigations which was made at that time and the co-operative agreement which was entered into with the different State health authorities and the International Health Board made possible a great expansion of malaria-control investigations. The number of officers engaged in these investigations was greatly increased and being widely separated in their assignments (Virginia to Texas) it was natural that the administrative duties at field headquarters should be similarly increased.

In carrying out these duties it has been the sole aim at malaria field headquarters to interpret correctly service policies and bureau instructions to the field force—to direct and correlate their investigations, to spend our allotment to best advantage, and to build up a field force of malaria investigators and an administrative system

which can be readily expanded to meet such future demands as increased allotments may make upon us.

The bureau rightfully insists upon having definite reports at stated intervals of the progress which is being made in malaria investigations and of other administrative matters; otherwise, the expenditures can not be justified to Congress. It has certain forms for these reports, definite rules for official correspondence, and printed regulations for the government of us all. The officer who makes no attempt to conform to these rules and regulations does not fit into the organized disease-fighting forces of the Government. And we who are engaged in malaria investigations belong to these forces because the final goal of all our investigations is health improvement. In order that we may work together to best advantage in obtaining this end, each and every one of us must perform the duties assigned to him to the best of his ability, remembering that we are all members of the same body and all working for the same end—*the investigation and solution of malaria problems.*

DISCUSSION.

MR. LE PRINCE. I think we are clinging too closely altogether to a procedure that was started 20 years ago. Back in the eighties Dr. Howard taught us all the value of oil in connection with mosquito control. The general scheme of malaria control and mosquito control was developed in the countries to the south of us, and we are following those lines too closely altogether: there is too much hand-work done; we haven't looked into the possibilities of other methods of control as closely as we should have done, and personally I am of the opinion that our mosquito-control work is becoming altogether too expensive. The mere fact that the public is ready to pay for mosquito-control work is not a sufficient reason why we should continue our present methods: we must have more economical and more satisfactory methods of procedure, and I think everybody should keep that point in mind.

I understand this past summer we have paid as high as 25 to 27 cents per gallon for oil that formerly cost from 4 to 7 cents per gallon. Labor cost is double and worth about half as much, so that I might state to-day we are getting from one-third to one-half in the way of a day's labor of what we used to get.

We must consider other methods: we must find if in a large part of this country we are not doing altogether too much ditching for malaria control. There may be certain parts of our work that may be omitted altogether. Investigation along that line is necessary. And I think that it is necessary for our service to consider possibilities along this line. If that is done, there will be as many of the service engineers available for field work along demonstration lines

as there has been in the past. It is certainly necessary to keep down costs, and I think everybody should keep that idea in mind.

Any further discussion?

Mr. ROSE. I don't know that I have any place on this floor, but I can't very well restrain myself from giving emphasis to the importance of the point that has just been made.

If we are ever going to succeed in this work, it is just as important to give attention to the dollar as it is to the mosquito; to the control on the one side and the cost on the other side. The question how can we cut expenses is important. The man who can devise a means whereby he can diminish the cost of this work has made a contribution that will be valuable to the work everywhere.

Dr. FERRELL. Mr. Chairman and gentlemen, Dr. Fricks has outlined quite clearly the plan of procedure which has guided in the cooperative demonstrations for malaria control during 1920.

A program for 1921 is being formulated. Those of you who have actually engaged in the work should be in a position to suggest modifications and changes which should be made. Perhaps you can suggest changes which will increase the efficiency of the work, lower the per capita cost for control measures, and permit the employment of a larger supervising personnel which may find continuous employment in public-health work directed to malaria control.

The 1920 plan for financing the cost of antimosquito measures contemplated the securing of as large appropriations as could be obtained from the towns, and that the remainder of the cost would be shared equally by the State board of health and the International Health Board.

The per capita cost of the work in six towns in Alabama averaged 80 cents, of which the towns supplied 40 cents, the State 20 cents, and the International Health Board 20 cents. In three South Carolina towns the per capita cost averaged \$2.95, of which the towns paid \$1.53, the State 71 cents, and the International Health Board 71 cents.

In Arkansas, Texas, and Tennessee the State boards of health had no available funds for the work, consequently the towns were called upon to supply a larger percentage of the cost for antimalaria work. The average per capita cost in 4 Arkansas towns was 57 cents, in 2 Tennessee towns 85 cents, and in 12 Texas towns 64 cents.

There seems to be some correlation between the per capita cost and the amount of money contributed by the State board of health for antimosquito measures.

One naturally inquires why the per capita cost runs high in certain States and low in others: and whether or not the results are determined in any degree by the amount of available funds from the respective agencies. In any event, it would seem desirable to shift as large a part of the cost for antimosquito work to the towns

as possible, so that the available funds of the State for the work may be used in strengthening the personnel and in an extension of the work.

I feel sure these discussions, together with a review of the work throughout the South for 1920, will prove stimulating, and that we shall be able to bring about a number of improvements next year.

Mr. LE PRINCE. A suggestion was made to me last night that it might be possible, in case of shortage of supervising engineers, for the towns themselves to bear a part of that burden. If they employ an engineer to do their work from other sources, as his term of service would be short, they would have to pay him a very much higher sum than the actual cost of the engineering supervision as now provided.

An expression of opinion from some of you that make the approach to the different towns will probably be more valuable than anything by me, and on this matter I think the State health officers can give us some very valuable information as to 1921 possibilities.

Mr. CLARKE. I made about 10 surveys in the hill section of Mississippi last year. I found that where the conditions were bad and good results could be had at small cost, we could get at least 75 per cent from the towns.

Now, I think, especially in the Delta territory which we will take up during the next season, that no doubt we can do as well as we have done in the hill section; because the work is greatly needed and will not be costly in the majority of cases. And, further, I believe that we could educate them up to the necessity of the work within three years so that they will put up 100 per cent, and the State board of health and the cooperating agencies would have only the overhead cost to bear.

Mr. LE PRINCE. I would like to hear from some 100 per cent men, those who have had the towns pay everything. There must be something in this manner of approach that could be brought out that will be worth while. Will some one of the engineers who has got the towns to pay all of the funds please give us some information as to the general method of approach, procedure, and so on?

Mr. MAGOON. I found that there was no difficulty in locating districts in Texas where the malaria problem was more than half of the health problem of the towns, and where local people could furnish all the money needed for the work.

There was sufficient time to make the detail surveys, and they were carefully completed in advance of the effort to have the agreements approved. All agreements were consequently signed without delay. It was necessary for one town to call in a banker and arrange to borrow the money for its campaign. Towns borrow money for sewerage and other things that are not as important as anti-

malaria work. This same town found it necessary to organize its work so that one full-time competent employee could be secured to look after the duties of tax assessor, tax collector, city marshal, street and bridge department, and sanitary inspection, including oiling and ditching. This year all revenues of this city amount to about \$3,000. This must pay for the full-time city employee, for any teams employed, for part-time city secretary, and part-time service of a negro who cares for latrines. Obviously this town can not have a separate organization for each activity it should care for. The mayor and city council appreciate the fact that they should care for the health problem of the town. Their full-time city employee is instructed that his first duty is to care for the anti-malaria campaign. While not engaged on that, he can take care of collecting taxes, putting up hogs, and other work of the city.

I believe the work of the director is to plan the work of the towns on such a scale that they can care for the antimalaria campaign and other essential work with the taxes that they may be permitted to levy. I believe the antimalaria work should be under the direction of the mayor and city council. The director should have nothing to do with time keeping, paying labor, and like responsibilities, but his duty should be to teach others what should be done, and plan the drainage work so that all the activities of the town can be carried on with a reasonable expense assigned to the antimalaria campaign.

Dr. FERRELL. Do you feel yourself at any great disadvantage in approaching these towns and being unable to offer them a certain amount of money as coming from the State board of health?

Mr. MAGOON. I found that I was at no disadvantage because I had the assistance of Dr. Harrison, one of the members of the Texas State Board of Health, who was so gracious in his explanations to the town in regard to my efficiency in the work that they were glad to make plans so that they could get my services.

Dr. HARRISON. It might be of interest to briefly outline our experience in Texas in organizing this work.

The work was first attempted officially during the last season, and, as Dr. Ferrell has stated, the State board of health was without funds to place at the disposal of this work. But we were assisted by the International Health Board and the Public Health Service. Then we started the actual work of organization, and in placing the proposition before the towns it was our intention to have the towns bear the entire expense of the work, except that of supervision, which was to be furnished them. That was the proposition that we made the towns. In Mr. Magoon's units we were more successful with that plan than in the other two units. The towns pledged them-

selves to bear the entire expense of operation, and they did so. The work was very successful, and those towns will continue to work during the coming year, supporting it entirely, with the exception of the supervision.

In Mr. Parker's unit we also made the same proposition; the towns pledged themselves, through the officials, to support the work in the same way. When we began actual operations we found that the towns hadn't sufficient money to carry on these operations except by asking for public subscriptions. They were only partially successful in that. One town did support the work entirely; the other three towns couldn't raise the funds even after pledging themselves to do so. It then became necessary to ask further assistance from the International Health Board. It was given to us.

In Mr. Hardenburg's unit the same proposition was put up, and the towns pledged themselves to raise the funds. The towns all carried out their pledge in his unit, but unfortunately it was found that there had been a slight underestimation of the cost of the work in that unit. It therefore became necessary to ask for assistance in his unit. It was also granted. That was the general status of the organization work.

Speaking just for a minute of plans for the future, we feel very strongly in Texas—and I am sure the cooperating agencies agree with us—that to make this work permanent it should be borne to a very great extent by the towns themselves, and we are planning not to organize any new work in Texas except on that basis.

In regard to increasing the appropriation for the work, we will not be able to obtain a regular appropriation from the legislature until next September. However, the legislature meets in January, and we have drafted a bill for an emergency appropriation of \$56,000 to expand our work.

As I stated yesterday, we have 105 counties in the malarial belt of the State, and we have been simply deluged by requests to extend this work. Therefore we have a very great problem to handle, so we intend to ask for this emergency appropriation. We also hope that this appropriation will enable us to employ sanitary engineers who will be paid by the State. In addition to that, naturally we want as much outside assistance as we can obtain.

I am very proud of the fact that Dr. Ferrell has mentioned that control work has been carried on in Texas at a very low per capita cost—I believe 64 cents.

Dr. HAYNE. I am deeply interested in this subject. I listen to these statements and figures and I don't know at times where I am at. One man will say that the per capita cost of the control of malaria is 50 cents in a town, and that is compared with some other town in which the per capita cost is as high as \$12.50. Is he talking

about the same thing as I am talking about, or am I talking about an entirely different proposition?

I want to bring out a few figures. We had in South Carolina a little town of 2,200 people, and they had malaria. They had plenty of it; and it wasn't necessary for an investigation to determine whether they had malaria or not; they admitted that they had it. They had reported 600 cases at one time, and the probability is the unreported cases would have amounted to at least 1,500 of the 2,200 inhabitants. Now, that is malaria, and that is a town that is interested in getting rid of malaria. In Bamberg, S. C., we had about 7 square miles of territory, requiring 52 miles of ditches. Some of these ditches were regular ship canals. This town of 2,200 people had to put up about \$17,000 of its own money in order to have this work done.

Now, we had other little towns, probably like the ones referred to, where we got along with 50 cents. Those towns didn't do anything that I know of except clean out a few ditches and do a little oiling, etc., and they decreased malaria to some extent. In this comparison of per capita costs let's have some standard to go by.

Now, as to whether you are going into the town and say, "You do all of this work and we will supervise it," or whether you say, "You put up half the money and we will put up the other half," depends on whether you have any money to offer. Of course, if you don't get any appropriation from the State board of health for malaria work, naturally you have to go to the towns and say, "You put up the money; I can't help you in any way." The only thing left for the town is to put up all the money. But these towns knew as well as we did that the State board of health had put up some money, and they wanted their part of it.

Now, our program in South Carolina is this: We propose to have a malaria division under the State board of health, with a competent engineer at the head of it. We believe that it is largely an engineering problem: we believe that there are some medical problems that enter into the control of malaria, but we believe that we have enough medical knowledge in the State board of health to supply the necessary medical knowledge to the engineer, so we are not going to put a doctor in charge of a division that will be almost entirely engineering work. We propose to ask our legislature for an appropriation of \$15,000 for this work. It is a large amount of money for South Carolina. South Carolina is a little bit of a State; probably it has 700,000 white people in it, and the Negroes don't pay taxes. Get that in your head when you talk about the amount of appropriation.

We are faced in the South, if not all over the United States, with a period of extreme stress—a period when you can not get hold of

money under any circumstances. I know of several instances in which men have gone to banks and offered to pledge their Liberty loan bonds and couldn't borrow 5 cents on them. Those are the conditions in my State. Now, when you talk of increasing appropriations under those conditions, the legislatures would be derelict in their duty to their citizens if they put an extra tax on them.

What we want to do is to tide over this period of 1921 until we get back into a period of prosperity again. To do that we are going to have to call on the International Health Board to tide us over 1921 in this malaria work. If we are going to do anything in 1921, it will be to hold what we have and not do very much more.

We have three towns that have agreed to continue the work which we have done, and we will have to have a competent man to tell them what to do and to see that they do it. Then we propose in two or three towns to do the same work, but not this intensive kind, where we picked out the most malarial place in the State, and it cost \$12.50 per capita, and it was worth it.

Dr. GARRISON. I think we are going to be confronted with many difficult problems with reference to securing appropriations, certainly from our legislatures. There are some of our old towns that are going to continue the work. Some of them may have to be coaxed a great deal; some of them may have to be assisted. I think the engineers who have been doing that work probably can answer that question now better than I can. Most of the towns have made promises, but my experience this year has led me to come to this conclusion: That unless they put up the money by the time work is to be begun in the spring we will not begin control measures. We have had some experiences this year which we don't wish to occur again in 1921.

I can't very intelligently discuss that question of administration because I did not hear it, but I think that we are all pretty generally agreed as to the plan of procedure. As to the agreement between the various agencies, there is one thing that seems to me must be definitely determined at this time, namely, what personnel can be guaranteed to the various States. I want to know that, if possible, now.

We have been asked to make surveys and I have written letters to additional units stating that preliminary surveys would be made for work in 1921, free of charge. Some of them have answered favorably; some of the surveys have been made and they report they are going to raise the money; others that they are going to try to raise the money. That is a very good report, and it is encouraging, but unless they do put up the money we are not going to undertake new work.

I want to know what to offer the old towns next year. I did not have enough personnel this year to secure necessary data and super-

vise them. As a result the work has not been as successful in the way of mosquito control as it had been in the past, and for that reason we have received some criticism. I want to give you one of the instances. In the city of Eldorado the Rotary Club requested that a survey be made. It was made, an estimate of twenty-four hundred and odd dollars was submitted, and the Rotary Club underwrote that amount, the city agreeing to pay something like four or five hundred dollars. After a great deal of trouble and argument the appropriation was finally actually secured. The work was begun. Along in midseason the engineer was taken ill for a period of weeks, and we simply couldn't relieve him, and during this time the inspector did a great deal of ditching which was unnecessary and expended several hundred dollars that was unnecessary, which rendered our fund inadequate to do the job well. As a result the Rotary Club is dissatisfied and I am to be called on for an explanation.

Unless we can get definite information as to the number of engineers we can count on next year we can not make out our program.

Dr. FERRELL. You have 4 new towns this year, and you had 10 towns under control previously—14 towns in Arkansas up to date; is that correct?

Dr. GARRISON. Well, that doesn't include Little Rock, which isn't in the joint program.

Dr. FERRELL. Might I ask what you contemplate in the way of a legislative program in securing funds to enable the State board of health to hold what has been begun in these towns?

Dr. GARRISON. I contemplate asking the State for \$10,000 annually for a period of two years, and I am going to ask the International Health Board and the Public Health Service to finance the rest. I don't know that I can get that \$10,000. That is my program. If I don't get aid from the legislature I would like to know how much supervision we can count on, so that I will know how many towns we can supervise next year.

Dr. FRICKS. Mr. Chairman and gentlemen, I want to point out to you the danger of our marking time in malaria control in the small towns and not investigating every factor that enters into malaria control and the future expansion and successful continuation of our work. Mr. Le Prince and Mr. Rose have mentioned one, which is reduction in cost. Another factor, it seems to me, of great importance is the devising of some plan through which this work is grafted on to the permanent health work of the State and the community. Personally, I feel that in the South the county is sure to be the local health unit. I am not here to tell you how you are going to graft your particular line of malaria control onto the health program of the county. Mr. De Mott has shown you how it was done in Nassau

County, in New York State. I can't tell you how it should be done in any particular community, yet it has to be done if the work is to be permanent. I feel that if we hold fast to that which is good in quinine administration, fish control, screening, drainage, and education, and properly select and combine the control measures suitable to any given locality, we will be able to extend malaria control throughout the rural communities of the South.

Mr. LE PRINCE. The next paper will be on fish control, by Mr. Parker.

FISH CONTROL.

GEORGE PARKER,

Sanitary Engineer, International Health Board.

For such a tiny fish the reputation and responsibility of *Gambusia affinis* are prodigious. Its rapid multiplication and insatiable appetite for mosquitoes in the aquatic stage render it of incalculable value in field operations directed toward malaria control.

Much has been said regarding the life history and the ability of *Gambusia* to adapt itself to various conditions. This paper means to deal more particularly with such items of interest as have been encountered during the past season in antimalaria demonstration work.

The town of Athens, Tex., having a population of 3,704, was selected to demonstrate malaria control through the exclusive use of *Gambusia*.

The chief industries in this town are the manufacture of bricks and other clay products. During past years many clay pits have been abandoned, and, for this reason, with few exceptions, some 35 ponds have been created well within the town limits. Nineteen of these ponds are located on the western side of the town hardly 1,000 feet from the courthouse building, which marks the center of the town, and are surrounded on three sides with dwelling houses.

On April 30 the work of stocking all ponds was commenced. A total of 14,720 *Gambusia* was placed in the 19 ponds mentioned. Their multiplication was rapid, and few *Anopheles* were found breeding up to the month of June when the heavy vegetable growth was completely removed. Four of these ponds were entirely free from this growth, due to their peculiar white clay banks. Dry weather which followed served to reduce the volume of water in the ponds and the edges were entirely free from vegetation. *Anopheles* breeding was under control. Inquiry and observation proved that the mosquito nuisance had been greatly reduced.

The effect of this work is best demonstrated by the following extract taken from a written statement made by Dr. J. K. Webster, city health officer, on September 1, 1920:

It is my observation that although there is more malaria in Athens this season than in previous years there has been but very little in the area of mosquito-control work. In fact, in my own practice I have had no call to a case of malaria within the area of the work done.

The preliminary survey of this town developed the presence of *Gambusia* in three bodies of water: One shallow pond on the southern border of the town, a large pond 1 mile north of town, and in a slow-moving stream, running northwest from the last-mentioned pond. This stream received the discharge from the septic tank, and at a point below this discharge, the largest quantity and best specimens of the fish were found.

It is well known that *Gambusia* seek out their own habitat when at liberty to do so, and in this instance they showed a marked preference for the stream leading from the septic tank. They were found in the small shallow overflows of this stream that contained the same class of water, and also in the stream bed where their presence could not be distinguished, except by their movement, on account of the color of the water. These fish were the largest and best specimens found and withstood rough transportation well.

In Jacksonville, Tex., a town where complete antimalaria measures were resorted to during the past season, *Gambusia* were used entirely to control *Anopheles* breeding in ponds, with the same result as prevailed in Athens. Some experiments were carried on at this point. Stock ponds provided with *Gambusia* were rendered entirely free from *Anopheles* breeding during the season, though water held in cow tracks at the edges of the ponds was a continual source of breeding and required constant attention.

In one lake the Star Head minnow, presumed to be *Fundulus nottii*, was present in a quantity considered sufficient to control *Anopheles* breeding. The edges of the lake were cleared of vegetation and the action of the *Fundulus* observed over a period of six weeks. *Anopheles* breeding continued and increased rather than diminished, though the breeding was not prolific. The lake was then stocked with *Gambusia*, and in a very short time *Anopheles* breeding was under control.

A *Gambusia* hatchery was established in this town early in the season. The *Gambusia* were collected from points ranging from 1 to 5 miles from the town and placed there to breed. Other ponds and lakes were either stocked from this hatchery or the fish placed in them when brought to town. The latter method seems to be the best to follow, especially when the collecting is being done early in the season, in order to allow the fish to multiply throughout the year where needed and reduce the original number necessary for stocking at a later time. A hatchery should, however, be maintained for other reasons. For instance, ponds and sluggish streams located a sufficient distance not to be considered a menace to the town from a point of mosquito flight, yet having their relative importance to the town, can be stocked from a hatchery, and the rural communities provided with these fish at will.

The effect of *Gambusia* on *Anopheles* has been mentioned in this paper, but so far the *Culex* has been given no consideration. Several observations along this line made during the season are worthy of mention.

The *Gambusia* hatchery in Jacksonville remained in first-class condition during the entire season. In no instance were the banks at the water edge grass grown. Repeated inspections were made for mosquito breeding in the pond. Never were *Anopheles* larvæ found, but on several occasions full-grown *Culex* larvæ were present. In two ponds to the south of this town, far enough from the area under *Anopheles* control to require no clearing, and with grass-grown edges, except for a few weeks during an exceedingly dry spell, *Gambusia* were placed toward the middle of the season. *Anopheles* larvæ were few after this period, and only occasionally was an *Anopheles* pupa located, while a branch and small pools a few yards distant contained them in abundance. The ponds contained *Culex* larvæ and pupæ throughout the season. This condition occurred in several other instances, including the ponds stocked with *Gambusia* in Athens. The places under observation were known to be adapted to *Anopheles* breeding, as the presence of this mosquito was marked prior to stocking with fish.

I do not mean to say that *Gambusia* will not eat *Culex* larvæ. In small glass bowls it was demonstrated that they do, and like them. This was also demonstrated in a section of ditch that remained wet after the greater portion had dried. This section was several hundred feet in length and about 3 feet wide. It contained prolific *Culex* breeding and hardly any *Anopheles*. After stocking with *Gambusia* the *Culex* breeding was practically eliminated in a few days.

Anopheles and *Culex* larvæ were put in a small glass bowl in equal numbers, with *Gambusia*, and the *Culex* were eaten first. This is attributed to the fact that the water was clear, and the fish, remaining below the surface, saw the *Culex* first as they dived for protection, while the *Anopheles* remained on top of the water near the edge of the glass bowl.

It may be said that *Culex* breed more prolifically than *Anopheles* and that this would be the explanation for my observations. I believe that it has something to do with it, but in stressing the point I think the *Culex* obtain better protection under natural conditions from the *Gambusia*, swimming at the surface, because they dive and are able to elude them by hugging the bottom in shallow water, while the movements of the *Anopheles* are visible at the surface.

As a natural enemy to the breeding mosquito the *Gambusia affinis* can not be overestimated, particularly in its action against the malaria-transmitting mosquito, *Anopheles*.

DISCUSSION.

Mr. LE PRINCE. I want to call upon Dr. Howard, who has done some very good fish-control work in Mississippi, and probably at other points in the past, to open the discussion of this paper.

Dr. HOWARD. I have heard Mr. Parker's paper with interest and satisfaction—with interest because it was very instructive, and with satisfaction because it confirms my faith in the *Gambusia* as a very valuable ally in mosquito control.

Since 1917 I have had in charge a rural area in Mississippi consisting of about 36 square miles, where we have been experimenting with the *Gambusia* as an agent of mosquito control. The area is purely rural in nature and has a population of 600 people. It is in the hill section of Mississippi, where corn and cotton are the main products, and where the usual methods of cultivation are employed.

In 1917 and 1918 our activities consisted entirely of making observations and studying natural conditions. During this time it was noted that the *Gambusia* was already actively functioning in many water deposits under natural conditions as a control agent in mosquito production, and it was early determined to employ the *Gambusia* as extensively as results would justify in our plans for mosquito control.

At the opening of the season of 1919 control measures were instituted consisting at first of drainage, training of ditch and stream channels, clearing away of vegetation, débris, edging, etc. Water deposits which could not be permanently disposed of by drainage were prepared and stocked with fish. At first some oil was used, but later the fish supplanted the use of oil almost entirely, so that by the end of the season of 1919, 90 per cent of all water deposits in the district were being successfully controlled with the fish.

During the present season (1920) we have maintained mosquito control in a like proportion of our water deposits with fish alone. As the season of 1920 opened we found that the majority of water deposits stocked with the *Gambusia* in 1919 had retained their complement of fish through the winter, and only about 8,000 fish were necessary to restock the entire area during the season of 1920.

In practically all of the water deposits of any size and of a permanent nature, the only work required during the season of 1920 was the clearing away of débris, falling leaves, and vegetation, to expose the mosquito larvae to the fish. In the district referred to there were 228 classified water deposits consisting of lakes, ponds, creeks, ditches, pools, potholes, dipping vats, cisterns, and springs. All classes of water deposits were stocked with the *Gambusia* with uniformly good results.

Our experiences and observations during the three years of our experiment convince me that in those sections of the South where

the *Gambusia* is indigenous, or in any section where it may thrive, it can be employed to great advantage in mosquito control, and I know of no agent of control which will function satisfactorily with so little supervision and preparation of the individual water deposit.

With reference to the occasional breeding of mosquitoes in water deposits stocked with the *Gambusia*, our observations agree with the statement made by Mr. Parker that it is the *Culex* which is most often found, the larvæ of the *Culex* seeming to be more often able to escape destruction by the *Gambusia* than the larvæ of the *Anopheles*.

MR. LE PRINCE. It is one minute of 12, and this discussion will be continued this afternoon. The meeting is now adjourned until 1.30.

Afternoon Session, November 16, 1920.

MR. LE PRINCE. I am going to call on Dr. Griffiths to continue the discussion on fish control. I know perfectly well, particularly on the Texas coastal plain and other sections, the fish are giving us very satisfactory results, but I want to know about places where they are giving poor results and what it is due to—whether you run across places where the *Gambusia* are unsatisfactory and just what the difficulties are, and any other pertinent remarks you wish to make.

DR. GRIFFITHS. Mr. Chairman, I have had no experience and no observation of places where *Gambusia* are useless. I believe they are of use wherever they occur, and that they have been an important adjunct, or ally, as the term was used by one speaker this morning, in keeping down malaria naturally; and in many instances they have been put into places where they have done valuable service.

One speaker referred to his relying upon fish control solely. I don't know of any place or any body of water in any part of the country where vegetation will grow where you can apply fish control solely. Probably on account of the peculiarity of the method by which they come into the world, the top-feeding minnow, in my estimation, requires "wet-nursing" in order to get it to do the things that we want it to do. The "wet nursing" consists in patrolling and cleaning your pond edges and in keeping them as near absolutely free as possible from vegetation and from floatage of different kinds in order that the top-feeding minnow may see the wiggle tail when it wiggles. I have seen *Gambusia* pass up to and actually touch the larvæ and not devour them until some motion was perceptible. The more floatage you have the less movement you are going to have on the part of the larvæ. I have never observed, except in artificial containers, the attack of the top-feeding minnow on larvæ except when the larvæ moved.

Some of the worst breeding places of *Anopheles* that I have ever seen were bodies of water that were well stocked with the top-

feeding minnow—naturally stocked—where the vegetation was of such a character as to afford hiding places, and the wiggle tails would not be attacked by the top-feeding minnow.

For control of malaria about impounded water or hydroelectric power projects it is important to early establish fish hatcheries and to supply these large bodies of water with top-feeding minnows. This is relatively inexpensive, and it is very important work. I would like to stress its importance, because Southern State health officers, if there are any of them here who haven't had these problems, will have them come up. In a great many waters there are already top-feeding minnows and they can be increased in enormous numbers and transferred to the reservoirs.

I do believe that whenever possible in malaria-control work every pond should be unwatered by drainage if feasible because of this one fact: You must depend upon the local community to continue this work, and it is easier to keep places unwatered than it is to do this "wet nursing" for the top-feeding minnow that I spoke of. Whenever the use of minnows in mosquito eradication would in any measure discourage the drainage operations that are more or less permanent and which the people will maintain better, I would certainly resort to the latter, the more permanent work.

There were several places in North Carolina where we did demonstration work. The *Gambusia* is naturally very prolific in those sections. We did some very good control work by cleaning pools and by keeping ditches clean for their action, and thereby cutting down oiling expenses, but wherever leaves dropped in the water, or the edges had not been sufficiently cleaned we invariably found *Anopheles* larvæ in various stages. You can not apply *Gambusia affinis* without also preparing your pools so that they can get around and do their work.

MR. LE PRINCE. We will hear from Mr. Hildebrand on the subject of fish control.

MR. HILDEBRAND. Mr. Chairman and gentlemen, in the main I agree with what has been said in regard to mosquito control by fish. However, the last speaker made a few remarks which do not agree with my observations. For instance, if I did not misunderstand him, he thinks it necessary to remove all vegetation from water in order to get 100 per cent mosquito control by the use of fish. This I don't consider necessary in a large number of conditions, depending in a large measure on the number of minnows that are present and the general biological conditions which prevail. I will come to that again a little later.

The reports this morning were certainly very pleasing to me, and I learned one thing that I hadn't observed, that the *Gambusia* is

more effective in eradicating the *Anopheles* than the *Culex*. An effort will be made to verify this.

I was rather disappointed not to hear anything of the cost of the work at Athens, Tex. It may be that Mr. Parker didn't have time to bring that out, but if time is available I wish he would do that yet. No actual figures of any work that has been done with fish are available, but I can state that in the summer of 1918, with the help of one laborer all the time, and two laborers part of the time, a large series of ponds, probably several hundred, around Augusta, Ga., was absolutely taken care of. You can figure for yourself what the cost was as compared with other methods, and we had absolute control, but we spent more money and did more work than was necessary because we couldn't afford to experiment around the camp there. We didn't use any oil in any of those ponds on the Augusta side at any time, with the exception of treating large floating masses of algal pads. We at first treated these algal growths with copper sulphate, which worked very satisfactorily, but this was more expensive and slower than simply to oil the pads.

Now, just a word about the history of fish control. The first practical test of this method of control that I know of, on any large scale, was made at Dallas, Tex., by Mr. Van Hovenberg about 1916. In the spring of 1918, upon the request of the Public Health Service, I was detailed to Augusta, Ga., to do the work of which mention already has been made, and my superior officer expressed extreme doubt as to the practicability of fish control. His information was derived from the work done at Mound, La., situated in the Delta region, where the minnows are so generously distributed that there is scarcely a place where a comparison can be obtained of the difference in mosquito production when they are present and when they are absent.

In the summer of 1918 certain ponds at Augusta were stocked with fish and I think they have about reached their natural biological possibilities at this time. I made careful inspections there last August and there are less than a dozen ponds that we stocked in 1918 which, without having received one bit of help since 1918, do not have to-day 100 per cent mosquito control. Compare this with a certain pond in the same vicinity built since 1918, and therefore not stocked with minnows, and which had become largely overgrown with vegetation, yet not as badly as some of the ponds in which fish are present and where 99.99 per cent mosquito control prevailed. In making dips in the very densest vegetation in ponds where fish were established we probably didn't average one larva or pupa, while the new pond, which supported no fish, yielded from 25 to 100 larvæ in one dip. I presume that this is exceptional, but I am not here to

state that that condition would not have prevailed in the other ponds if the minnows had not been present.

Now, I made some investigations this summer and have given particular attention to the distribution of *Gambusia*, and this interesting fact has come to my attention: That *Gambusia* is limited almost entirely to the malaria belts. For instance, in Austin, Tex., which is not in a malarious section, although some favorable bodies of water are present, only a very few top minnows were found upon an extensive investigation. The same is true at Atlanta, Ga., and at Nashville, Tenn.

The matter mentioned by Dr. Griffiths concerning the attraction of *Gambusia* by the motion of the wiggler is interesting and important. *Gambusia* does not seem to have developed good eyesight, for very often, as Dr. Griffiths said, it will nose a wiggler but will not take it, but the moment it moves that wiggler's life is lost. The range of sight appears to be limited to about 3 inches, and, of course, it is usually essential that we do not have too much vegetation to protect the wiggletails and to hide their movements. On the other hand, I have seen perfect mosquito control under the most unfavorable conditions imaginable with respect to plant growths. I refer to a lake at Perry, Fla. Mr. Foster will bear me out in that statement. I want to state, however, that we have at Perry, in addition to the *Gambusia*, another fish, the smallest American vertebrate, *Heterandria formosa*. Now, that may be a factor there, as it is much smaller than *Gambusia*, and I imagine it can get through and over vegetation where *Gambusia* can not go.

Mr. LePrince has given me a large amount of liberty, and I shall take advantage of that now. He told me to tell the sanitary engineers what they did that should not have been done and what they did not do that should have been done.

I was very greatly pleased with the general attitude of the sanitary engineers toward fish control, and I think that the Public Health Service can congratulate itself upon the able men it has. I found them extremely earnest and enthusiastic as a rule. Now, the main criticism that I have to offer is that insufficient time is devoted to inspections. I realize that the sanitary engineers have a great amount of work to do, and many things to attend to, but inspections, if they can not make them themselves, can be turned over to assistants in a large measure. We can not know what is going on in any body of water unless we examine it. I will say this: Before I would do any work on a body of water, such as cleaning out vegetation or floatage of any kind, I would want to know if it was necessary. Take the example at Perry, Fla. If Mr. Foster had attempted to clean out the vegetation from that lake, it would have cost hundreds of dollars and it would not have been

necessary; but he simply kept on inspecting from time to time and found it unnecessary. A similar condition prevailed at Thomasville, Ga. However, later in the season it became necessary to give this pond a cleaning, but if the sanitary engineer had not been on the job and kept it under observation he would simply have said: "This is a bad place; we can not get mosquito control here without cleaning it." I was there in August and made an inspection. We did not find any large larvæ, but we found small ones. Mr. Old did find mosquito production there late in the season, and it became necessary to clean this body of water once.

That, I believe, is about all the criticism I have to offer, except that I might give an instance of some work that was done simply because time was not taken to see whether or not the work would be necessary. A certain pond, which I had designated a hatchery, was drained. It was a pond in which such conditions prevailed that I feel certain that not one mosquito would have come out of it the past summer.

The sanitary engineers may have their reasons for doing that kind of work, but if they are primarily concerned with the control of malaria, then such drainage work should not be done. Of course, if it is desirable to reclaim land, that is a different thing altogether.

Now, to make my position perfectly clear, I want to read just a few pages from a rough draft of a report that I have just written and which may be published in time. This report is subject to revision, and before we get through with the discussion this afternoon I desire to make some changes. I have tried to make myself clear, but still I found that somebody every little while says that this man Hildebrand claims that fish will do it all. I never made such a statement, for I thoroughly appreciate that fish control has its limitations. [Reading:]

Top minnows are of great value in controlling mosquito production in all permanent standing bodies of water, if in fact they are not the only agent known to date which successfully controls mosquito breeding in ponds and lakes. It has been demonstrated that top minnows are also very useful in sluggish ditches and streams, for at Savannah, Ga., all the ditches of the abandoned rice fields which supported top minnows, even though in many instances quite extensively overgrown with vegetation, were under almost perfect control during the latter part of the mosquito-breeding season of 1920, when the writer made inspections at frequent intervals. Identical results were observed under similar conditions earlier in the season of 1920 at Gulfport and Biloxi, Miss., Wilmington, N. C., and many other places. Minnows also are used in borrow pits, pools, potholes, cisterns, and shallow wells. It frequently is feasible to use fish more economically than oil in temporary pools and

ditches, depending upon how near at hand a supply of minnows is available, and generally upon the length of time such temporary waters will remain. It probably seldom is practicable to use fish when the waters dry up in less than one month yet occasionally stocking a pool with fish is less expensive than one application of oil. Under such conditions it is an advantage to oil pools remaining even a shorter period than one month. The situation, with respect to the available supply of minnows and the cost of applying oil, in such instances must determine which method is the more practicable. It is sometimes an advantage to dig a pit in the deepest part of a temporary pool or swamp which may hold enough water to carry at least some of the minnows through a period of drought.

Top minnows may be used under at least the following conditions under which oil can not be used to advantage: (a) In ponds and lakes where a continuous film of oil can not be maintained because of being driven to one shore by wind action. (b) In waters used for drinking purposes, whether for man or beast, where oil is objectionable. (c) In places where there is tall vegetation which breaks the oil film, but which very frequently does not hinder mosquito control by fish. Conditions produced by plant growths, of course, exist under which absolute control with fish may fail, but under such conditions practically the same process of cutting and removing vegetation is necessary to secure control either with oil or with fish. Fish control being of a much more permanent character than oiling, therefore is preferable.

Fish control, aside from the cost, has the decided advantage over oiling of being very much more permanent in its results. Oil, as is well known, must be applied throughout the summer at intervals of from 7 to 10 days, and during rainy weather oftener, to secure mosquito control. The writer has not seen a permanent body of water where the fish were once established where they did not remain, unless killed or driven away by pollution. The many ponds at Augusta, Ga., which either were already naturally stocked or which were stocked artificially in 1918 were nearly all under perfect control in August, 1920, the fish, in many instances, having greatly multiplied, while in other ponds a biological limit of production probably had been reached in 1918.

The relative cost of mosquito control with fish or with oil for a single season has not been well established, for no data on somewhat similar situations have been collected, but it is evident that if top minnows are available in a given locality, and they are abundant almost everywhere in the malarious sections of the South, then the cost of fish control consists merely in distributing the fish, and, in some instances at least, the fish must be assisted by removing vege-

tation and floatage which furnish hiding places for the immature mosquito against fish. When oil is used, the cost of the product with present prices is a large item. The cost of distributing and spraying the oil at frequent intervals undoubtedly is greater than stocking the waters with fish in the same locality, under the average conditions obtaining in the malarious sections of the South, and the removing of vegetation and floatage is sometimes necessary whether using oil or fish. It, therefore, is quite evident that as far as fish can be used certainly the cost of the oil is saved by employing fish, with the further advantage that the mosquito control obtained with fish is not limited to the first season but will continue indefinitely.

Conditions, of course, exist when oil can be used to advantage and when fish are worthless. Fish, of course, can not be employed where a mere film of seepage exists or in footprints, and it frequently is not advantageous to use fish in very temporary pools, ditches, and swamps. Top minnows frequently do not work well in swiftly flowing creeks which, however, have quiet coves and pools. It therefore, because of the small cost and the more permanent results, seems advisable to use fish under all conditions under which they will provide mosquito control and to apply the oil treatment only when fish can not be successfully used.

Drainage undoubtedly deserves first place among the measures of mosquito control because of its permanent character, but it is a recognized fact that all water deposits can not be eliminated. The cost of drainage is usually high and therefore in many localities prohibitive. It is not always possible to replace control by drainage with fish, i. e., when the breeding areas consist of waters which will not support fish, but it is quite feasible to employ fish in all permanent standing waters which are not polluted or overpopulated with large predaceous fishes. Fish control is especially recommended for rural sections and for other localities when funds for the more expensive measures are not available. Certainly a great reduction in malaria can be obtained by the judicious distribution and protection of top minnows.

Dr. GRIFFITTS. I would like to ask what method you employ to transfer minnows from one pond to another. Also has it been your experience that lily-pad ponds don't produce *Anopheles*, as a general rule, in sufficient numbers to be of sanitary importance?

Mr. HILDEBRAND. Dr. Griffiths's first question relative to the transporting of top minnows: I have used lard cans frequently, although the standard method seems to be milk cans. The lard can is preferable to the milk can in some respects, although it is harder to handle in shipments. The amount of water you should use and the number of fish to carry is a thing regarding which each man has to

use his own judgment. If the weather is hot, you should not carry over 50 minnows in a 60-pound lard can, but if the weather is cool, I think you would be safe in carrying, say, from three to five hundred. The weather conditions must govern very largely, and, of course, the temperature of the water is the important thing. We have had heavy losses in transporting fish, and again we have transported large lots and lost practically none. Also it seems that weather that is hot and sultry, particularly when there are showers, is a bad time to transport fish. You should transport fish either at night or on a cloudy day.

As to the lily pads, where we find them along the surface of the water, they will not do any damage; but some of the reeds are constantly dying, and oftentimes they form a clump which can not be reached by fish. When that condition prevails the lily pads must be removed, and I think that ordinarily this can be done at a small cost and probably it would be advantageous to do it at once; but I have seen instances where it was very expensive, and individual conditions would have to govern.

MR. CLARKE. I would like to ask what are the chief enemies of the *Gambusia affinis*.

MR. HILDEBRAND. The worst enemy of all is the fish that is generally known in the South as fresh-water trout, in the North, the large-mouthed black bass. From observations that I have made it isn't the adult fish so much that does the damage as the small ones that venture into the shallow water; for instance, a large-mouth black bass from 3 to 4 inches in length. Pike and pickerel also feed on fish. I think more important enemies are the water snakes. I believe it is advisable to kill the water snakes just as far as possible around the ponds where we wish to establish fish control.

(The conference gave Mr. Hildebrand a rising vote of thanks.)

MR. ROPES. Mr. Chairman, I would like to say in defense of the engineers that one reason we have for draining places such as Mr. Hildebrand mentioned is because it is obvious that fish control will not be permanent. I have had perfect fish control in several borrow pits, but grass has now begun to grow around the edges. Now, next year, when I won't be there, there will be grass all around the borrow pits, and although fish control is perfectly adequate this summer it will not be so next year.

We had a great many *Gambusia* in Arkansas this year and we found them perfectly effective wherever the vegetation was kept down. Just as soon as this is omitted, so that the *Anopheles* are protected from the fish, there is plenty of breeding.

MR. STROMQUIST. My work in the field, by personal association, has given me the greatest admiration for two individuals: First, Mr. Le Prince; second, *Gambusia*. We had in a town of about 6,500

population in Tennessee an appropriation of \$5,000 for this season's work, out of which we saved \$2,700. The difference between the actual cost and the estimated cost is entirely due to the presence of *Gambusia*, and I think it doesn't quite coincide with Dr. Griffiths' statement about *Gambusia* not being suitable for lands that are overflowed, because our great problem was river bottoms, which during the winter are overflowed, and when the water went down it left a number of sloughs and ponds, which were well stocked with *Gambusia*, and we didn't do a foot of ditching there.

Last summer I was called to a little village about 20 miles from Memphis. At this village there was an artesian well overflowing into a stock pond which in turn overflowed into a pasture. There were about 2 or 3 acres of this pasture covered with water up to 6 inches deep, with such a dense growth of grass that the water could not be seen. I dipped quite thoroughly at this place, and in a great number of dips found only three or four *Anopheles* larvæ, but in several dips caught *Gambusia*—sometimes as many as three in a dip. I think the *Gambusia* provided effective mosquito control at this place.

MR. VAN DINE. The work on fish at Mound, La., has been mentioned. We must be careful not to compare investigation with control. Our conditions are these: We have a typical swamp country; we have these fish universally distributed; there is an universal production of *Anopheles* and we have a prevalent rate of malaria.

The fish are undoubtedly one of the greatest natural agencies that we have in mosquito control, and it is a big point to take hold of that agency and make use of it wherever possible.

The investigation at Mound was an attempt to see what reduction occurred in that environment. We failed to measure their usefulness, but I would certainly hesitate to take the responsibility of removing those little fish from that environment. No one can estimate their effect on production of malaria mosquitoes in that region, but the conclusion is that such reduction is not sufficient to prevent universal density of *Anopheles* sufficient for prevalent transmission of malaria.

Dr. Griffiths, in speaking of the use of these little fish in ponds, makes the statement that wherever the pond can be drained that would be the method of choice. In the work that Dr. Howard mentioned in Mississippi there are a large number of ponds where it is not practicable to either drain or oil. I refer to the stock pond, a farm necessity. Those ponds must be maintained, and it seems to me that drainage is out of the question in a country where those ponds are typical.

Fish control is not only an adequate solution, but the only practical solution for these stock ponds.

There is one biological point that I want to suggest in regard to the enemies of the top minnow that I have not heard mentioned. The predaceous fish are not to be regarded from the standpoint of the reduction of the little fish, but viewed in the light of the police patrol work on their part in keeping the little fish where they belong. Now, as an example, we have a certain body of water with a certain number of these little fish and we have certain results, yet in that same body of water if you have a given amount of other predaceous fish you get an increased amount of control. These little fish, instead of wandering about wherever they want to go—sometimes the very place they ought not to go—will be right where they belong along the margin. Their salvation depends on being there, and when you get differences in results under the same conditions it may be that the presence or absence of the predators would explain it.

MR. MAGOON. Mr. Chairman, this last summer I found it possible to control *Anopheles* breeding in 55 ponds with very little cost for labor. In fact, but few of these ponds required having the edges cleaned, and it was not necessary to clean the edges of any pond more than once during the season. Inspection of ponds on the 5th of November indicated that the fish control was still satisfactory. *Gambusia* were alert in getting any *Anopheles* that were collected elsewhere and put into the water. The unexpected effectiveness of *Gambusia* control was an important reason why the cost of mosquito control in four districts averaged less than half of the estimates.

MR. FUCHS. I should like to call the attention of the engineers here, and Mr. Hildebrand, to a situation where drainage was cheaper and more effective than fish control. In North Carolina we had some ponds that were very shallow, whose banks had a very gradual slope, so that even a slight rain would increase the area of the pond tremendously, and a slight evaporation would decrease it very much. The result was that between the period of high water and low water—these periods came frequently—a great deal of vegetation grew up along a wide shore area, so that any attempt to clean the edges of those ponds would have resulted in a cost that would have been prohibitive when compared to drainage work. In these cases I preferred drainage, which would once and for all take care of the ponds, to the use of fish and the cutting of vegetation. I found that the vegetation in many such cases was so thick that *Gambusia* could not thoroughly take care of the *Anopheles* breeding. This is just one of the situations where, from a viewpoint of cost, drainage is preferable.

MR. LE PRINCE. I would like to hear of some similar occurrences to that reported, in places where fish have been unsatisfactory. Those who operate in sections where fish are decidedly satisfactory must realize that there are limitations that are met sooner or later.

Mr. DAVIS. I agree with Mr. Hildebrand and the others that fish are probably our best natural help in the control of mosquitoes.

The area that Mr. Hildebrand referred to in Savannah, early in the season, was a prolific breeding place of *Anopheles*. After the vegetation was removed and the water confined to the ditches the fish controlled breeding absolutely, even though later in the season a rather dense growth of vegetation covered the ditches almost completely.

In another part of the town we had a large drainage canal with an entirely different class of vegetation. It is well stocked with fish, but we found *Anopheles* breeding in abundance. It was necessary to remove this vegetation twice during the season to allow the fish to do the work satisfactorily.

Dr. GRIFFITS. Mr. Chairman, I want to talk just one second on the political relation between fish control and your local problems. What I mean by the political nature of it is this: Are the people going to be satisfied with a lot of eyesores, a lot of roadside pools and ditches, that they think they are paying for the drainage of, and on which they may get the impression that the engineer is out fishing instead of working? These are bad looking places. I don't care if you clean them a half dozen times a year. There may not be a single wiggletail in there all summer long. We must think of the impression it is going to make on those people, when we go in there and say "We will ditch or fill these places," and then we fail to do so, but depend on fish control, which the people don't see. That is one point that we all ought to bear in mind. People drive along the road and say "There is a place that the engineers left."

Mr. STROMQUIST. I agree with Dr. Griffiths that we must often consider the psychology of the people we have to deal with. At Brownsville, in taking up subscriptions for their part of the work, one man said to me he wasn't going to pay any money to these fellows to go fishing, and the first work we did there was draining a pond which possibly might have been controlled with minnows, but I am not quite sure they would have been entirely effective. It was located right in town only two blocks from the courthouse square, and it has been an eyesore to the people for years and the cause of a good deal of controversy with the owners of it.

Mr. VAN HOVENBERG. I would suggest that one of the best ways of enlisting the help of the children, such as the Boy Scouts, would be to establish aquariums in the prominent store windows throughout the town, and by teaching the Boy Scouts the practical value of *Gambusia* in the streams.

Mr. PARKER. In regard to the cost of the work at Athens, in answer to Mr. Hildebrand's question, the contemplated campaign was estimated to cost about \$3,000, which amount the town was not

in position to pledge, so we decided to put on a campaign of fish-control. The total amount expended, including help from the Cotton Belt Railroad, was probably \$800. In areas outside of towns under control *Gambusia* were placed in ponds and no clearing attempted. In such places I can safely say that we got very close to 80 per cent *Anopheles* control. There was a growth of Bermuda grass along the edges of those ponds which was very thick and hard for the fish to penetrate, so I think it would be well to consider what effect the *Gambusia* have on a pond before the vegetation is cleared away. They will give at least 75 per cent control unless conditions are very bad.

That is a method I had in mind of reducing the expense of the work. As considered from a standpoint of mosquito flight, I think we can control communities very easily by the use of *Gambusia*. In a great many instances *Gambusia* placed in sluggish streams are carried on through the county, as I found them in streams 10 or 15 miles away from where I placed them in the headwaters. They washed down stream and gave a certain measure of mosquito control in different parts of the county, which cost the people in those sections absolutely nothing. The use of fish is one way in which work can be extended through the county at practically no cost with a good measure of mosquito control.

MR. LE PRINCE. I would like to have a few remarks from Dr. Barber.

DR. BARBER. In the course of observations in the Southwest last summer my chief impressions regarding fish control have been two. First, the effectiveness of such control during spring and early summer when aquatic vegetation is relatively less developed. Second, the effectiveness of the aquatic vegetation of summer and early autumn in protecting larvæ against fish. Enormous production of *Anopheles* was observed in rice fields and in the pools and ditches adjacent to them in spite of an abundance of minnows.

A point worth consideration—a matter which has undoubtedly been well developed by Mr. Hildebrand—is the possibility that the maximum of *Anopheles* production, and with it, perhaps, the onset of the malarial season, may not be postponed, in some localities at least, by the activity of fish in spring and early summer while aquatic vegetation is sparse.

MR. LE PRINCE. Do you care to make any remarks, Mr. Hildebrand?

MR. HILDEBRAND. Referring to the places where minnow control apparently failed, I believe this to be largely due to the fact that not enough minnows were present and that the competition for food was

not great enough. It isn't always possible to increase the competition, but sometimes it is.

I want to mention an experiment we conducted on a ditch in Savannah. We had quite a heavy mosquito production in that ditch, but we added 7,000 minnows to this comparatively small ditch, which was at the time completely isolated, and within about one week 100 per cent control prevailed.

Mr. LE PRINCE. We have heard the talk along the line of the necessity of county work. Now, there is other work, agricultural drainage work, being done in counties, and where the State health officers are beginning to have sufficient agricultural drainage work done that will lessen the amount of mosquito work you will have to do.

We are fortunate in having with us Mr. McCrory, in charge of that class of work for the Department of Agriculture, who will read a paper.

AGRICULTURAL DRAINAGE AND ITS RELATION TO MALARIA CONTROL.

S. H. McCrory,

*Chief, Division of Agricultural Engineering, United States Department of
Agriculture.*

The wet swamp and overflow lands of the United States have an area of more than 100,000,000 acres. In their present condition these lands are unsuited for agricultural uses and in certain sections of the country constitute a menace to the health of those living nearby. The timber has been cut from most of these lands and in their present condition they return but little income to their owners.

That the drainage of these lands would have a beneficial effect upon the health of those living in many areas in the South is, I believe, generally agreed. Looking at this problem from the viewpoint of the sanitary engineer it is probably desirable that these lands be drained as soon as possible; there are, however, other factors than the public health that enter into the problem. Nearly all the land is in private ownership and the desires of the owners must be considered in any undertaking which affects the condition or use of these lands. The area of land now in cultivation in the United States is probably large enough to grow all the crops that our present population needs. From an economical standpoint an increase in the area of cultivated lands should be made only as our population increases or the demand in the markets of the world increases. An overproduction of food-stuffs is apt to have a disastrous effect on both agricultural and industrial efforts. This year we have grown the largest crops of corn and rice that the country has ever produced and large crops of cotton, wheat, and other staples, yet, despite these splendid crops, our farmers are complaining that they are not prospering.

In the past supply and demand have to a large extent controlled the development of our wet lands and if our farmers are to continue prosperous any plans for the drainage of our wet lands should not bring more lands under development at once than can be utilized without serious overproduction. It is doubtful also if labor is now available to place large areas of newly reclaimed land under cultivation at this time. Many other factors affect the problem of developing our unused lands and it is one that deserves careful study by all interested in order that a sound policy may be developed.

The drainage of our swamp and overflowed lands has been accomplished in the past mainly under the provisions of the State drainage laws. All States having any considerable area of wet lands within their boundaries have passed such laws, and all of the Southern States, with possibly one exception, now have workable drainage laws whose validity has been approved by the State supreme courts. The details of the various laws differ considerably in different States but the main features are substantially the same. In general, the laws are drawn upon the supposition that the proposed improvements must benefit either the public health, the public welfare, or the public convenience. The projects are initiated by petition of the requisite number of landowners to the proper official. On receiving the petition an engineer or board of viewers is appointed who makes a preliminary survey and files a preliminary report upon the project. If the project is to be established, the report must show that the project will benefit either the public health, the public welfare, or the public convenience, and that the benefits resulting from the construction of the proposed improvements will be greater than the cost. The official to whom the report is made upon receipt of the preliminary report, fixes a day for a public hearing and notice is given to all interested landowners in order that they may appear and protest against the establishment of the district if they desire. At this hearing a finding is made for or against the establishment of the district.

If the finding is in favor of the district the proper official orders it established, final surveys are then made, bonds sold, contract for the construction let, and the improvements recommended built at the earliest possible date. The cost of the improvements is assessed to the lands benefited, usually according to the benefits received by each parcel of land. Throughout the proceedings the interests of all landowners are carefully protected and they are given opportunity to appeal to the proper authorities for relief from any apparent injustice. Usually the cost of the work is met by issuing drainage bonds, which are later repaid by the collection of the assessments upon the lands in the district. Such bonds bear from 5 to 6 per cent interest and are exempt from all Federal income taxes, which makes them a very desirable investment for persons of large income. This, in brief, is the method followed in organizing and constructing drainage systems.

Under the provisions of such laws about 5,000,000 acres of our wet lands have been included in drainage enterprises in the nine Southeastern States, or approximately 10 per cent of the lands needing drainage in these States. The cost of this work to December 31, 1919, as reported by the Bureau of Census, has been \$28,532,545, or an average cost of \$5.70 per acre. It should be remembered that not all the land included in these drainage enterprises has been com-

pletely reclaimed, and it is probable that by the time the reclamation of the land now included in drainage enterprises is completed, the cost will be at least twice as great, or approximately \$11.50 per acre. Much of this work was done before the increase of prices for such work and the cost of future undertakings will be somewhat greater, due partly to the increased cost of the work and partly to the more difficult character of the project. When we realize that the first modern drainage law in the Southeastern States was not passed until 1909, it is apparent that considerable progress has been made in draining our wet lands. In a little more than 10 years approximately 10 per cent of the wet lands in the Southeastern States have been placed under reclamation, or at the rate of 500,000 acres per year. Had it not been for the war, which practically stopped drainage work, the areas would have been much larger.

Experience with these projects has shown that if adequate drainage is to be secured the projects must be carefully planned by competent drainage engineers and that construction work must be properly done. One important lesson that we have learned is that the drains must have sufficient depth, and that they had better be too deep than too shallow. In territory where drainage work is just beginning the tendency is always to make the ditches too shallow. This should be guarded against in all new projects. Under ordinary conditions 8 feet should be considered the minimum permissible depth for mains and submains; 10 feet is better if it can be obtained. A small ditch of proper depth is generally more effective than a ditch of considerably greater capacity that is too shallow. Much information in regard to the design of drainage projects is now available and can be found in the technical journals and in the bulletins of the United States Department of Agriculture and the State agricultural colleges. There are some precautions that, from the standpoint of the sanitary engineer, should be taken on every drainage project. Care should be taken that openings are left in the waste banks at all low-point places and at the points where old watercourses are crossed, and the engineer should insist upon having a good smooth finish to the banks, berms, and bottom of the ditch. Practically all specifications for drainage work provide for this but the specifications are usually not carefully enforced. If openings are not left in the waste bank, water is certain to collect back of them and stand there until it seeps away or is evaporated. Such ponds afford breeding places for mosquitoes. This water is objectionable also from the standpoint of the construction engineer, as it tends to make the waste banks cave, thus obstructing the ditch. A smooth uniform finish is most desirable, especially on streams where the flow is intermittent, as when the work is roughly done water is left standing in the bottom of the ditch in pools after

the flow stops. Aside from the benefit to health that may result from the elimination of such pools our investigations have shown that a well-finished dredged ditch will carry at least 10 per cent more water than one poorly finished. Field ditches should be replaced by tile drains as rapidly as possible, as most field ditches now afford a breeding place for mosquitoes; the field ditch is expensive to maintain, occupies a considerable part of the land, and interferes with the use of modern farm machinery. On many farms the cost of keeping the ditches in condition will more than pay the interest on the money required to pay for tiling the land. There is no more effective way of removing water from the land than by tile. Much of the wet land in the coastal plain region responds readily to tile drainage, and as the sandy nature of the soil permits deep drainage and wide spacing it can be drained at a relatively low cost. On most lands the benefit to crops is more than sufficient to warrant tiling, to say nothing about the benefits to health.

Clearing the timbered land after it is drained seems to have a considerable effect upon the health of the community; this is probably due to the fact that when the land is cleared and placed in cultivation the low places are ditched out and the sun and wind reach the soil more readily, causing a higher rate of evaporation.

While much land has been drained and to a large extent utilized in the past 10 years, from the standpoint of the farmer, it is not desirable to drain the land too far in advance of the time when it can be utilized for farming. Some one has to pay interest on the cost of the drainage work and for the depreciation in the drainage ditches after they are constructed. If this is done a considerable time in advance of the time when the land is placed in cultivation, it adds considerably to the cost of the land, generally without any resulting benefit to the farmer, unless it be from benefiting health conditions in the entire community. If this benefit to health is to be made a strong argument for undertaking drainage projects primarily for sanitary reasons, much more educational work will have to be done before it will be supported by the interested farmer. In my judgment, it is very doubtful if in sparsely settled communities the time has yet come when such projects should be undertaken, but in the well-populated regions both economic and health conditions usually warrant large drainage projects. The lands along the small streams of the Piedmont region of the South are typical of such streams. In the coastal plain region of the South if 25 per cent of the lands in a given section are in cultivation and the land is wet, a drainage district will generally be a good investment. I have long thought that more should be done toward the elimination of malaria and the work that you are doing is one in which I have been and am

greatly interested. In your efforts to educate the public generally in regard to the benefits resulting from eliminating malaria the facilities of the department for disseminating information might in some instances be used to advantage. The Extension Service, through the county agent, the home economics agents, and the leaders of the boys' and girls' clubs, is able to reach a large part of our rural population, and in this work they are the joint agents of the Department of Agriculture and the State agricultural colleges. The Extension Service is only one of the mediums through which the department reaches the farmer. Other agencies are bulletins, press service, and the services of specialists in various lines of work. The Division of Agricultural Engineering, Bureau of Public Roads, carries on what work the department does in relation to farm water supply and farm home sanitation, and we shall always be glad to assist any of you who may be interested in getting in touch with the proper officers of the department, and so far as our resources permit to cooperate in any way possible. If the American farmer is to be as successful and efficient as he should be, it is essential that he and his family have good health and proper living conditions. We hope that your work will be so successful that there will be a general improvement in the health of the rural population.

DISCUSSION.

MR. LE PRINCE. Questions are in order. I am going to begin this discussion by asking Mr. McCrory one question which I think we ought to know about. Have you had many applications for assistance from the county health officers or the State departments of health who could benefit largely from the work of your division?

MR. MCCRORY. We have had a few requests from county health officers and in one or two instances from State departments of health. I believe there is one drainage district in Georgia that was initiated by a request from one of the sanitary engineers in the employment of either the State health department or the Public Health Service.

MR. STROMQUIST. I would like to ask Mr. McCrory if in establishing drainage districts there is any fund provided for maintaining the drainage canals.

MR. MCCRORY. Most State drainage laws make some provision for maintenance but usually it is not enforced.

The problem of maintaining our drainage ditches is one of the most serious that confronts engineers engaged in drainage work. There are a few districts in Arkansas and Mississippi, and probably a few in the other States, where they are doing maintenance work, but much more should be done than is now undertaken. Maintenance is desirable from two standpoints: it enhances the efficiency of the drainage district and it benefits the health of the community. We have made

investigations on the effect of maintenance on the efficiency of the ditches, and we are convinced that with an annual expenditure of from 1 to 2 per cent of its cost the life of a drainage ditch can be greatly lengthened, and that with regular maintenance work the expenditure required for maintenance will be very much less than if the policy now generally followed—that of digging the ditch and allowing it to deteriorate until it becomes useless and then redredging—is pursued. We made some experiments in Mississippi on the capacity of drainage ditches that had not been maintained and on those that were maintained. Maintenance increased the capacity of the ditches about one-third.

It is interesting to note that many defects in the construction of ditches, such as lack of openings through waste banks, which result in water standing back of waste banks, rough finish, and similar defects which have a bad effect on the life of the ditch are objectionable from a sanitary standpoint, while good work where these objectionable features are eliminated makes for better sanitary conditions. The work of the drainage engineer and the sanitary engineer is closely related, and it would be to the benefit of the public if there could be a much closer relationship on drainage projects.

MR. FURUS. I should like to ask Mr. McCrory to give us a little data, if he has it, on the relative cost of tiling and open ditching, and as to whether the cost of tiling is prohibitive for farmers and property owners in general.

MR. MCCORRY. Open ditches for outlet drains will cost from \$7.50 per acre up in the coastal plain region of the South and from \$30 an acre up in the Piedmont section. These ditches are necessary for outlets for field drains, whether the latter are tile or open ditches. Tiling at the present time costs from \$40 an acre up to possibly \$100 an acre. One serious difficulty that is confronting men engaged in drainage work at the present time is the difficulty of securing tile. Prices are high—abnormally high. Labor has been scarce, and the cost is getting to a point where the farmers feel that it will not be profitable to install drainage. I think that until there is a material readjustment of the cost of tile and labor and the price of farm products, little tiling will be done. Under normal conditions in the coastal plain regions of the South the increased yield from the tile-drained lands pays a large return on the cost. Small ditches for draining fields will cost less than half as much as it would to tile the land, but such ditches require maintenance, occupy considerable land, and over a period of 15 or 20 years will cost more than it would to tile the land.

DR. FRICKS. I would like to say just one word about cooperation between the engineers engaged in agricultural drainage and the engineers engaged in drainage for health purposes. I had the pleas-

ure of discussing the matter briefly with Mr. McCrory in Atlanta a few days ago. It has always appeared to me that such cooperation is highly desirable. I have also had the pleasure of discussing this matter with the Surgeon General of the Public Health Service, and I find that he is heartily in favor of a program in which the two governmental agencies can cooperate for the improvement of health and living conditions in the South. I trust that the chairman and Mr. McCrory will be able to discuss this matter while they are here together and will be able to prepare a memorandum for the Surgeon General and the authorities in Washington upon which a cooperative program can be based.

Mr. CLARKE. I would like to ask Mr. McCrory if there is any satisfactory method of removing willows from ditch banks. I have noticed that where they grow there are potholes, and these potholes—a chain of them through the ditches—dry up; and then, after a rain, form again. Fish control in a case like this is out of the question. As to killing the willows, is there not some solution of poisons, which could be applied to the roots, that would be effective in getting rid of them?

Mr. McCORRY. With proper maintenance the willows should not be allowed to become established in the ditch. As effective a way as any of keeping willows down would be to sow the berms and ditch banks with Bermuda grass or some other grass suited to the territory, and then pasture the land. This would keep the willows and other trees down in fairly good shape; or, the willows and other trees can be pulled each year, or if large, cut down. The Forestry Service has a formula that will kill trees of various kinds. In some places it has been used very successfully; in other places with not such good results. The time of application, possibly, has some effect upon the results obtained. I am unable to give you that formula from memory, but it can be secured by writing to the Forestry Service at Washington. With proper maintenance of the ditches no willows or other trees would be allowed to grow on the berms or banks of the ditch.

Mr. STROMQUIST. It seems to me that cooperation between the county agricultural agents and other agricultural organizations and the health authorities will be very valuable, but at the same time I think that a sharp line of demarcation should be made between the two activities. For instance, if we sanitary engineers went around and told the farmers something about farms, we might give a good deal of misinformation. The same thing might be true of agricultural engineers, who had a very superficial knowledge of health work, attempting to give information about sanitary work.

Mr. FISHER. I should like to ask Mr. McCrory whether there is some provision made by law for maintenance work.

Mr. McCrory. In most States there is some provision made for maintenance, but usually that feature of the law is honored in the breach rather than in the observance.

Dr. GRIFFITHS. Most of these drainage laws include provision for the protection of the public health, and in their preambles land drainage seems to be secondary to the matter of public health. I should like to ask Mr. McCrory if, in any of the States, after these drainage laws are in operation, the health end of it has not been entirely ignored. You may, in some instances, greatly increase the production of *Anopheles* and decrease other types in swampy areas by confining the water without current in the deep drainage ditches.

A year or two ago, I went through drainage districts in North Carolina and inspected some of the canals installed four or five years ago. I found *Anopheles* breeding in canals and conditions favorable for malaria should the locality be populated.

Much of the malaria danger could be obviated by putting a "ditch within a ditch"—or a small ditch in the bottom of the canal. In many cases this would result in lowering the maintenance cost of the canal. I discussed this matter at the National Drainage Congress last year and I remember that Mr. Vaughn, of Wisconsin, said that for years he had finished canals by taking out the last shovelful in the center, and that he had done it solely for the purpose of holding down maintenance cost. I would like to know your opinion about this.

Mr. McCrory. Some of the drainage ditches that have been constructed in North Carolina, I have felt, were probably of little benefit to health conditions. I have in mind particularly those in Robeson County, which I have followed very closely. The bottoms of the ditches were covered with a dense growth of grass, cat tails and similar vegetation, making an almost ideal breeding place for mosquitoes. We have conducted some experimental maintenance work in that district. We made a small low-water channel in the center of the large ditch, cleared out the vegetation, and cleared the banks and berms. The carrying capacity of the ditches was made as large as when first constructed. The top minnows were given access to the shoreline, and breeding places for mosquitoes were practically eliminated. While we are not able to control the growth entirely, yet with the limited work that we were able to do we improved the conditions very materially in the ditches on which we worked, and we could see the effect of that work two years afterwards when we went back to do more maintenance work.

My experience with drainage ditches has been that their effect on the public health is forgotten after the ditch is constructed. This has always seemed wrong. Careful maintenance of the ditch would be in the interest of better drainage and better health.

In regard to the small ditch in the bottom of the large ditch, it depends almost entirely on your soil. If you have a stiff clay, the small, low-water ditch will work well; but in the sandy lands, such as are found in the Atlantic Coastal Plain region, it is doubtful if such a ditch would last long enough to be of more than temporary benefit.

MR. LE PRINCE. I wish to call everybody's attention to the fact that Mr. McCrory prepared and read a very interesting article on drainage operations as conducted by his division at the meeting of the American Society of Agricultural Engineers, and those of you who are interested in these drainage matters should get a copy of the proceedings of that society and see the article. We thank you very much. Mr. McCrory. [Applause.]

The next paper on the program is "Organization of malaria control division in State board of health," by Mr. L. M. Fisher.

THE ORGANIZATION OF MALARIA-CONTROL DIVISION IN STATE BOARD OF HEALTH.

L. M. FISHER,

Associate Sanitary Engineer, United States Public Health Service.

If I comprehend the object of the demonstration work in malaria control that has been done during the past few years, it is to induce the doing of more and more and still more malaria-control work until the whole remaining section of the country in which malaria is prevalent shall have been cleaned up. This is going to be a big task and one not lightly to be tackled without definite plans for its accomplishment. Since malaria control is primarily a health measure, it seems logical that malaria-control work should be carried out by health organizations. In addition to the health features of malaria-control work, however, there is the tremendously important economic aspect which makes its appeal strongly to the business man. He sees it as a scientific tool with which to increase profits. The health officer sees it as a means for reducing morbidity statistics and death rates. The business men in the malarious sections have not been slow to see the advantages of malaria-control work derived by neighboring towns where malaria-control work has been carried on. They will look to the existing health agencies for assistance in the work. And the existing health agencies are not at present prepared to undertake it, or even to give adequate assistance.

The argument is sometimes advanced in some quarters that because there are some 37 Federal health agencies doing work they should all be brought under one public health service. This may or may not be good reasoning.

There are always two sides to every question. Should not the fact that there are so many agencies be regarded as an indication of the inefficiency or inadequacy of the organizations that were in the field at the time the newer agencies entered?

I do not believe in the unnecessary multiplication of organizations for accomplishing the same purpose. If the existing organization can be used it should be used. If it does not make itself useful or adapt itself to the accomplishment of the objects the public expects of it, it must expect new organizations to enter the field. And the fact that the present laws give it exclusive jurisdiction will not permanently

preserve it from encroachment or curtailment of its field of activities if it fails to perform the service for which it was created. Eventually the presence of two organizations doing the same work will lead to waste and increased inefficiency at the expense of public funds, and the more useful and more aggressive will dominate the field.

It is a delicate problem in adjustments to harmonize and coordinate the aims and policies of two separate organizations engaged even in the same work. The interdepartmental jealousies that are found in so many of the branches of our Government are illustrative of this point. With a multiplication of the number of the organizations the problem is not simplified. It is seldom in life that conditions are as satisfactory as we could wish. We must make the best of the situations with which we are confronted. And often surprisingly satisfactory results can be accomplished. It often happens that the development to which an organization attains is very different from what it would have been had it been possible to plan it at a later date in the light of earlier experience.

The work in which a number of us find ourselves at present is a strange mixture of scientific or quasi-scientific investigation, propaganda work, organization, the administration of philanthropy, and the discharge of some governmental functions. Our fight against malaria seems to be in a state of semiorganization in many places. The division of the Federal Government devoted to scientific investigations has been seized upon and made to direct the fight. This has occurred because to many it appears to be the most logical agency to direct a nation-wide campaign against the disease.

In a certain sense the control of malaria is a local or regional health problem, or at least one that concerns only the State. But in another sense it is a serious national problem because of the fact that it affects such a large portion of the country and perhaps somewhat indirectly the whole country. The Nation and the State are therefore both interested in its solution, and should both be actively engaged in working out the problem; the efforts of the one should supplement those of the other. Because government is slow to appropriate money for expenditures which result in indirect benefits, and because the work of educating the public to appreciate and understand the magnitude of these indirect benefits is a slow process, private philanthropy and commercial and industrial interests find here an attractive field in which to work. Striking results have been attained for sums expended.

For geographical reasons and in order to benefit by the machinery of organization already in existence, the State health department is the logical place in which to set up a division in which the activities can be best coordinated and directed.

From such a division, advice, helpful suggestions, a certain amount of direction and supervision should be supplied to the people of the State. A study should be made of the malaria problem in every community requesting it, regardless of whether a demonstration could be made there. Every farmer should be able to get advice in solving his malaria problem. The more forehanded and intelligent citizens of the State are beginning to demand such a service. Individuals, corporations, and communities are willing to pay the actual cost of the work but desire to know that they are working along the right lines and to receive proper direction and guidance.

The work that has been done as a demonstration is attracting attention and causing new inquiries. As fast as people learn that their State government has taken up the fight against malaria they appeal for advice and assistance. To meet this demand there should be set up in the State board of health a division devoted to this work. So much for the needs of the immediate present. Let us look somewhat into the future if possible.

I believe that sooner or later the Nation will recognize its obligation to assist that portion of the country where malaria is present, not alone out of considerations of philanthropy but because it is good business. When the time comes that such moneys will be available it is conceivable that Congress will stipulate that the supervision of such expenditures be, to a certain degree, at least, in the hands of officers of the Federal Government. It is a comforting thought that our President-elect when in the Senate favored such appropriation and will no doubt continue to do so.

Malaria-control work is largely a question for the engineer. It is not primarily a medical problem by any means. There is a phase of it, namely, quinine prophylaxis, which is medical, but antimosquito methods of control, which are more positive in their results and more frequently used, are almost purely engineering. Medical science is interested in the control of typhoid fever, but the safeguarding of our public water supplies, the construction of sewerage systems and sewage treatment works are engineering problems and have played an extremely important part in the prevention of typhoid fever in our large centers of population. So also the engineer will play a very important part in the prevention of malaria.

Aside from the purely engineering features there are involved problems of organization and administration, problems with which the engineer in his work is frequently confronted. Because of these considerations it is probably advisable to have a competent engineer at the head of the division of malaria control. In fact, in a well-established board of health having a competent engineering organization it might be made a part of the engineering division. But the

work is of such importance and the field so specialized that a separate division in the department seems to be desirable.

Because of this the head of the division should report directly to the State health officer. Close touch should be maintained between the head of the division and the State health officer in order that there may be complete harmony in the policies which are to be carried out. The details should of course be left to the executive head of the division, but broad general questions of policy should be worked out with the State health officer.

There is a decided advantage, it appears to me, in having a representative of the Federal health agency as the executive head of the division. This comes in the comparative ease with which he can get several local health agencies to cooperate with each other and with the State in a given undertaking. Take the case in which a county and city organization should cooperate with the State and possibly other agencies in doing a given piece of work. It may be that the city at some time in the past tried to get something out of the State and was not entirely successful. It will nurse the grudge. In the same way there may be a spirit of jealousy between the city and county and between county and State, or more correctly speaking, between officials of these civil organizations. They are much quicker to lay aside these grievances when approached by a disinterested third party, an agent of the Federal Government, than when one or the other of the three assumes the rôle of mediator.

Organization plays a large part in our daily affairs. Sometimes I dream of the time when large sums will be made available for malaria-control work. Just where this money is to come from is a problem not easily solved. I have a scheme in mind which may be visionary to a degree, yet I can not help but feel that it could be worked out if sufficient energy were employed and enough people interested. Briefly, it consists of quietly raising a good-sized sum to be available over a period of one or two years, say of several hundred thousand dollars by individual subscription, to be used in a campaign of education, to inform the business men of the United States of the money loss they were suffering annually because of malaria in the South, to inform the philanthropically inclined of the tremendous amount of misery and sickness occasioned innocent people because of malaria, and to point out how, by the doing of a certain amount of permanent work, this could be prevented. We give hundreds of millions to the heathen, and to people who spasmodically fly at each other's throats in deadly warfare, and leave our own population to be decimated by preventable diseases.

This campaign of education and propaganda could be carried on by a concern specializing in community leadership or by a league of chambers of commerce and a preliminary organization effected.

Funds could be collected by the American Red Cross or by special commissions, and a nation-wide sentiment built up against the spread of malaria that would induce Congress to make helpful appropriations.

If such a scheme could be worked out the division of malaria control would be one of the connecting links between the money on the one hand and the field work on the other. If nothing along such lines ever develops, it is not unlikely that sooner or later Federal aid will be given and the States that have the nucleus for a well-organized division of malaria control will lead the way in reclaiming some of the most fertile lands in the country and making it habitable for the white race.

In summing up, it is desired to call attention to the following points:

1. The control of malaria is a problem of major importance to State boards of health in the South, and one that is only just beginning to receive the attention that it deserves and which an awakened public will insist that it receive.

2. Because malaria is not a serious problem in some of the more fully developed and richer Northern and Eastern States, where well-organized health agencies exist, we can not use them as models after which to build. We must devise something to meet our requirements.

3. Because of the importance of malaria-control work and because of the magnitude of the problem, and for other reasons, the head of the division should report to the State health officer.

4. Because of the predominance of engineering features, problems of organization and administration, included in the program, a competent man, preferably with engineering experience and training and special training in malaria-control work, should be placed in charge.

5. In order that the State health officer should not be placed in the embarrassing position of receiving a gratuitous service and not feel free to direct, and in order to make it possible to obtain a competent head, the State should contribute to the salary of the director, or at least the director should hold a commission from the State government.

DISCUSSION.

Mr. PARKER: There are 105 counties in Texas in the malaria belt. Tentatively a plan was approved by the State health officer, on my suggestion, of extending the work. I selected a territory to extend from the western border of the malaria region to the Louisiana line. About 50 towns were selected out of that region, all of which I had a clear idea would be able to support the work without outside help.

The plan was that the State health department would maintain a man in the unit that had been under control this year; that the director of that unit would move on to another unit that would be in direct railroad communication with the old unit, so that he might supervise it and the work being carried in the old unit. It was deemed necessary to have more than the usually haphazard statistics on these towns before we went into them to make surveys. So in the 50 towns that were selected for surveys it was suggested that some man be appointed by the State health department to precede the surveys to gather accurate malaria statistics and institute a system of case reports.

Under these conditions the engineer operating in that section has laid plans for expansion by having complete data available on a number of towns scattered over an extensive territory. Preliminary operations of this nature will tend to create an interest in the different sections and greatly simplify work when it is commenced, and most important of all allow work to be done at a lesser expense.

With such a large number of counties requiring malaria-control measures very little could be accomplished in a reasonable time with the extremely small personnel now operating in the State, should county-wide campaigns be conducted. In spotting the work systematically over the State it is believed that the greatest State-wide results can be obtained, as the spirit of the work seems to radiate from any central point where operations are under way, and at a later date the systematic joining of the number of units created could be undertaken.

Dr. HARRISON. Mr. Chairman, I should like to say that we in Texas heartily agree with the suggestion of the first speaker; that is, that a division of malaria control should become a part of the State health department, with a man at the head of such a division who could rightly be considered an expert to direct the work.

In regard to the plan that Mr. Parker has suggested, the State health department did tentatively approve that. However, it will be extremely interesting to us to have some further discussion of that plan. I would like to ask Dr. Fricks, and also Mr. Le Prince, to discuss this plan for just a minute or two.

Mr. LE PRINCE. I call on Dr. Fricks for his opinion.

Dr. FRICKS. Mr. Chairman, I don't think I am in a position to discuss this plan very fully at the present time.

We all realize that the cooperating agencies, the Public Health Service and the International Health Board, have not yet been able to decide exactly our financial status for the next year. If that is what Dr. Harrison means by discussing it, if that is the information that he is anxious to get—and I understand very readily how he would like to know—I will say frankly that I am not in a position to give

it at the present time. So far as discussing it in a general way, I might do that.

Personally, I can't help but feel that the movement is toward the county health unit and that ultimately it will be the basis of our health work all over the South. I may be wrong about it, but that is my personal opinion. But, on the other hand, we haven't got far enough to determine just exactly the best procedure to be adopted for all States. I am sure we all realize that the same measures which would apply in Texas might not apply in South Carolina. I appreciate very well your distances and sparse population.

It seems to me that it is the duty of the State health authorities to consider this matter carefully and formulate a program for the extension of malaria work. In the work which we are carrying on we are not going to be hidebound, and if the State health officer of Texas, after discussing this matter with Mr. Parker, feels that that is the best plan for Texas, why I am sure that Dr. Harrison and the cooperating agencies will be open to any argument or reasonable conclusion which they may reach.

I should like to say one word in regard to Mr. Fisher's paper, without making any comparisons. I realize that the sanitary engineers worked under different conditions, but I know what Mr. Fisher has done in South Carolina in regard to establishing a malaria division or nucleus for future malaria work in the State health department, and I think it was fine.

Mr. LE PRINCE. I believe that we ought to have a malaria-control division in each one of at least 14 of the Southern States. It is possible that it is a little early yet to have those divisions, but I think in the past a mistake has been made. Our health departments of the South, many of them, are relatively young, and probably there has been too big a tendency to copy the health departments of the States farther north. I am not referring to any one State. Our health problems of the South are different, decidedly different, from what they are in the North, and therefore the arrangements of the budgets for health work in the Southern States I personally feel should be entirely different from what they are in the North. Not only that, but the budget for one State need not necessarily be the same as that for the adjacent State.

I believe you are going along in the right direction at the present time, so as to get the public to see the need of and demand anti-malaria work, and when you get them thinking seriously along those lines I don't doubt but that you are going to have State appropriations for the antimalaria work. We ought to have started working for that five years or more ago.

I believe in not letting any work fail if it is possible to keep it up, and I do believe that we can find, in any demonstration area, a good

local man who gets his first training as foreman and then the second year, or later, can act in the capacity of supervising foreman, so that the engineer will just have a general supervision and see to it that things can not go far wrong. That will be the means of the engineer doing a lot of work. I don't know whether that was the general scheme Mr. Parker outlined or whether I got off the track.

I have spoken with three men who are working in Texas and they seem to think that the time is ripe for county work. Then it looks as though the time is still more ripe for the organization of a division for malaria control within the State. I do believe, however, that as money seems to be the hard thing to get there ought to be cooperation between the health departments of those Southern States interested in malaria work, so that we can get a very good malaria film that will not only appeal to people, but will make that appeal be heard so that we can be sure of sufficient public support when the State health officials attempt to get the appropriation they need. We haven't got enough backing; we want the backing of the people, who are not going to be denied, and if the proper film is gotten up and used in three or four States in doing county work through the malaria belt, so that everybody knows about malaria, its causes, and the facility with which it can be controlled, I think the demand for the appropriation for the State board of health will be very strong and there will be more of those voted into power who are favorable to public health work.

Mr. STROMQUIST. I think there is no doubt in the mind of any of us that a malaria division in the State board of health in each of the malarial States is necessary and that a sanitary engineer should be in charge of such a division; but I think about the most important factor in the success of an antimalaria campaign is the inspector—an inspector with four qualifications: A pair of strong legs, more than an average amount of common sense, plenty of pep, and an interest in the work. If you have such an inspector your chances are very much increased for putting on a successful campaign. With such an inspector we could supervise more work, and what we need is to train such men for the work. I think it would be a good idea to have them partly under the control of the State board of health and not entirely under local control, so that they could be used in different places and on different kinds of work. Thus you could assure them permanent work all year round.

I think Mr. Magoon's idea of amalgamating a number of city jobs is a very good one, particularly in towns of the size he has been working, in which I understand, there are populations of only eight to ten hundred. A town of that kind can not pay much for a marshal, inspector, and other positions, but if a good man can be found to

combine these jobs and in the malaria season devote most of his time to that work the town can afford to pay such a man a living salary and get a good man.

We are hoping in Tennessee to use the balance of the local funds that were appropriated for mosquito work this year to employ a full-time sanitary inspector to work with the city board of health. Members of this board of health haven't got time to go out and make inspections, but if they have a sanitary inspector to work under their direction they can do a good deal of work in improving sanitary conditions of the community.

Mr. SHAW. I think the situation as it is at present is very unsatisfactory to the engineer in the field. Of course, I realize we have been in the formative stage of the work, conducting demonstrations, but it appears to me that we have now reached the point at which it is necessary to organize or formulate some plan whereby the State and municipal organizations will take over the work. We all know that with further extension of the work it will be impossible for the Public Health Service to furnish supervision for every town. The cooperative plan must terminate at some time in a particular community and it will then be necessary for the local officials to take entire charge. The work of encouraging the continuance of malaria control and of advising where necessary will become the duty of the State board of health, for which purpose they should be forming a malaria division.

After the first year's demonstration the town should be prepared to continue the work with only general supervision, first by the Service, but as soon as possible by the State board's representative. But it appears that the tendency of both the municipal and State authorities is to unload on the engineer in charge and not take an active interest in what is being done. This attitude was clearly expressed by the health officer of a certain town. After I explained the general plan of our operations and stated that during the second year we would give general supervision, he said, "I will help you as much as I can." It seems to me that after one year's demonstration the situation is just reversed—the Public Health Service, the International Health Board, and the State board of health will help the town as much as possible.

Dr. GRIFFITHS. Mr. Chairman, things usually appear to me as either black or white. I am a little inclined to be too much that way, and not to see the intermediate colors, but I do think that ultimately the people have got to protect their own health. We are not doing work to-day for the mere purpose of making beautiful charts, or for the number of feet of ditches we put in it at so much per. Our work is building for the future—what effect we can have upon malaria 20 years from now or 25 years from now. Is there a possibility

of completely eradicating malaria, or stopping its existence as an economic factor—as a factor that tends to lower the physical manhood of this country, so that, if we are called upon again we won't be faced with a 25 per cent physical deficiency?

Now, we must reach the people. We have said for years that this is a rural problem, and up to this time we have been almost cruel to the rural people—we have neglected them, and they are the sinews of the Government. It seems to me that for the next few months, when we will not be digging ditches, when we will not be chasing the festive *Anopheles* or the pestiferous *Culex*, it might be well for the officer in each State to consult with the State health officer and to make a study of each State health organization with a view to deciding on the best way to carry on the next year's work, whether through the county units, through State propaganda, or other methods.

I might state that there are different opinions among State health officers as to how this problem should be met. Some State health officers may take the attitude that it could be worked out better under the supervision of a physician than an engineer. I have heard such expressions.

Others take the attitude that it is better to have it an engineering division. Others will say, "Why not attach it to our rural health work and get it established in our county units as soon as we can?" In some instances the overhead can be cut down greatly by so doing.

If we study these conditions very thoroughly with the State health officers and submit a report to headquarters, I think we can arrive at a very sane conclusion as to what we shall do next year, and what we shall do toward the future control of malaria.

Dr. HARRISON. I should like to say that our idea in regard to establishing a malaria division was that the head of the division should have the responsibility of raising the funds for the work. Our idea has been that the engineer is unquestionably the man to carry on the operations, but we have found some of the engineers rather loath to assume the responsibility of raising the money. Therefore, they have suggested in Texas that a doctor connected with the State board of health should go out and make the financial arrangements. We feel that whoever is the head of the division should be the man to assume that responsibility. If the engineer will do that so much the better.

Mr. LE PRINCE. I would like to make the statement that where possible the engineer ought not to have to do all the financial work; the engineer is there to do engineering work. Now, in the work that is going on on such a large scale in New Jersey and one of the counties in New York, the financial arrangements are all made, and the man who is directing the antimalaria control work does not have to

bother to get the money. He is there for another purpose; he is there especially to do a certain class of work, and it is a loss of time for him to have to go into the other work. I think that stand is perfectly correct.

Mr. PARKER. Mr. Stromquist, I think, brought up one of the most important questions that has come before us in regard to the extension of the work; that is, holding the services of the men we train. It is not necessary that we have a trained engineer, or a trained director as general foreman in a unit that has already been put under control. We can take one of the men who has been trained in one of the several towns under operation. At the present time I have a man who is ready to undertake such work if I can place him on the pay roll of the State board of health or take care of him in some other way for 12 months of the year. His services have been absolutely gratis the whole year. He knows how to proceed and is just the man that we need to leave in charge of such work, and he can take care of the four towns that have been under operation this year.

Mr. LE PRINCE. Mr. Fisher will close the discussion.

Mr. FISHER. It seems to me that the present uncertainty of plans for the future justifies any arrangements that will remove the uncertainty and give us something definite with which to work on. I believe that that uncertainty might be to a large extent eliminated. This plan necessarily calls for the expenditure of some money for administrative purposes to be controlled by the malaria-control division. Some of the details which it would have to perform would be to collect statistics and to prepare publicity articles and direct and supervise the use of moving picture films throughout the State, prepare a budget of expenses and take it to the State legislature, and be prepared to defend the items contained therein.

The big problem is to build up a personnel who can be used for this kind of work. I might point out that one weakness of the present arrangement appears to me to be the difficulty of holding trained men. There are certain contingencies arising at headquarters, which we in the field do not know about, and certain considerations make it advisable to send a man into the State who may be the only man available, and he may not like the State; he may not like the particular kind of work, and on that account may not fit in. If a man can be obtained locally and trained into the work it would be by far the best arrangement. We have found it very difficult to find any local man of sufficient intelligence, ability, and interest to undertake the work in any place where we have worked in South Carolina, so that we had to import talent. At one place we were fortunate in securing a man who had a good deal of training in the sanitary corps in the Army, and he is now remaining in the town

where he worked as permanent health officer for the city, and to that extent is adding to the personnel, which should become a part of the division.

This is a problem, of course, for the future, and, as has been pointed out, we are just now going through the formative stages, but it certainly behooves us to develop definite ideas and have them clearly in mind as to just how such a division could be effectively organized and as to the details with which the organization will function. It is hard to determine just what they will be and perhaps impossible to standardize them for all States.

Mr. LE PRINCE. The next paper will be "Railroad malaria work," by Mr. H. W. Van Hovenberg.

RAILROAD MALARIA WORK.

H. W. VAN HOVENBERG,

Sanitary Engineer, St. Louis Southwestern Railway.

Since so many of the men here are familiar with the malaria work being done by the St. Louis Southwestern Railway Co., I will only sketch our work briefly, inasmuch as a report embracing the past four years is to be published soon by our line.

Malaria control on the Cotton Belt dates from the interest of Mr. Edwin Gould, chairman of the board of directors, in the discovery that about one-third of all the medical treatment in the hospital was due to malaria patients. He enlisted the aid of the Public Health Service, and, following a field survey, actual work, both in the protection of employees and in offering cooperation with cities, was started under the direction of a sanitary engineer employed by the railroad.

The problem of malaria control on a railroad is complicated, due to the fact that its employees are scattered along many miles of line, live under varying conditions, and work both day and night. Many employees live in so-called camp cars that are moved from point to point over the line, as, for instance, bridge and building men. These men spend a large part of their time in the river bottoms, where there is a splendid chance for malaria infection. Trainmen may live in a division point, but spend half of their nights at other points on the line, where they may not have protection from the malaria mosquito. Railroad malaria control, then, is one of applying the remedy best suited to each particular case.

The starting of malaria control in a town is an old problem to you men. The St. Louis Southwestern Railway particularly stressed the cooperative plan of malaria-control work in the cities and towns along its lines.

I would say that in the beginning the railroad supplied practically all the funds for malaria field work. During the past year, however, practically 75 per cent of the cost of the work was supplied by the cities.

Following a study of the hospital records as to which departments of the railroad supplied the most malaria, it seemed practical to begin our work in our large-shop towns. This made it possible

to protect a large number of employees and to furnish the same protection to their families. The protection of men living in camp cars was effected through screening of their cars and teaching them the value of swatting mosquitoes in cars.

In order that we might demonstrate the economical side of malaria control to the management, we cooperated with several large lumber mills. In one instance we demonstrated that the mill production could be increased 20 per cent in one year, leading to a material increase in the freight revenue from this one mill alone.

We have used all practical methods of malaria control known to us, including a demonstration as to the practicability of quinine in prophylactic doses. During the past year we issued quinine rations to section men over 360 miles of main line. The result of this demonstration will be published soon.

Through the Public Health Service we have established a full-time technician in our employees' hospital, greatly increasing the efficiency of the hospital as well as aiding materially in sterilizing men who have been employed for years on the railroad and who could have been giving but a small part of their energy because of chronic malaria infection.

The St. Louis Southwestern Railway management saw fit to equip an exhibit or demonstration car for the purpose of teaching malaria control directly to the men employed over the system. This car was also used in stimulating the interest of school children in Texas and Arkansas. Our plan was, briefly, to enter a town and to get in touch with the principal or mayor and arrange to have the school dismissed so that one class at a time could visit the car. A talk was made to the children in language they could understand, stressing the part that each one of them could play in mosquito abatement. We asked the teachers to examine the children on what they had heard and seen. On return visits to several of these towns we found the children to have been very receptive.

Rather than offer financial aid to the cities in Arkansas as we have done in Texas, I thought it best to spend the same amount of money in educating school children. We hope that when they become business men and women in these towns they will be more than willing to establish malaria control and adopt other essential sanitary measures.

The result of four years of malaria work on the Cotton Belt has been to enlarge the work of the sanitary engineer to include all phases of health protection. A full-time organization was found imperative to carry on malaria control work successfully. This led to the adoption of a sanitary-control program which includes malaria control, water supply, station sanitation, heating and ventilation, quarantine, camp-car sanitation, station grounds beautification, etc.

I predict that in a few years sanitary engineers will be employed by all modern railroads. Our railroad managers will find that it will pay better to keep employees on the job rather than to pay for their hospital treatment. For such work as I have just outlined a sanitary engineer is eminently fitted.

I would like to stress the value of knowing the number of malaria prescriptions in relation to estimating the prevalence of malaria in a community. Mr. George Parker has demonstrated that an estimate of the amount of malaria, based on a study of the doctor's prescriptions, will check within 1 or 2 per cent with the actual cases of malaria. Another evidence of the general prevalence of malaria is the amount of newspaper advertising carried by chill tonic manufacturers. These people necessarily know just how much malaria there is in a community by following the sales of chill tonics, and their advertising will keep pace with the amount of business they do.

I believe it is important to know the amount of malaria in a town compared to other diseases. The number of malaria cases alone does not mean much to the average person when his support of malaria campaigns is solicited. He is interested though when you say, "Ninety per cent of all the medical prescriptions in this town are for malaria." He knows then that the enormous bills paid for medical and doctors' services are due to malaria alone, and that is a very strong talking point.

DISCUSSION.

Dr. FRICKS. We should all feel proud of Mr. Van Hovenberg's work in malaria control, because it is good and because he is one of us. I know he is still one of us in heart. I have been very much impressed with his work, and we have begun malaria surveys on other roads in the South with the hope that we might accomplish approximately as much on these roads as Mr. Van Hovenberg has on the Cotton Belt. We are now making malaria surveys on two roads, the Central of Georgia and the Illinois Central; and, Mr. Chairman, we have here as a guest Dr. Beach of the Illinois Central road, whom we should be pleased to hear.

Dr. BEACH. I have listened to the excellent paper presented on "Railroad malarial work" with greatest interest and pleasure. The railroad which I have the honor to be with, the Illinois Central, has, with the cooperation and assistance of the United States Public Health Service, undertaken a survey over the portion of the system in which malaria prevails, and will consider the employment of active remedial measures which may be recommended as a result of this survey.

I desire to earnestly recommend to those interested the necessity of getting in touch with a first-class publicity man, one whose

newspaper experience and ability as a writer will enable him to present the absolute necessity of cooperative antimalaria work to the public—let the public understand what we are trying to do, not by one write-up, but by a series of write-ups appearing in various papers which circulate through the country in which work is being done. This feature of the campaign I consider a great necessity, for until the public is in close touch and entire sympathy with the movement, money for necessary expense will be slow in coming.

With the splendid success accomplished by Mr. Van Hovenberg, of the Cotton Belt Railroad, there should arise the spirit of emulation among all railroads, and it is greatly desired that the next year will see the furtherance of this work until malaria becomes only a memory.

Mr. LE PRINCE. The next paper on the program is "Publicity," by Mr. E. H. Gage.

PUBLICITY.

E. H. GAGE,

Sanitary Engineer, International Health Board.

Publicity is the act of making a thing known to the "plain people of the land." As applied to malaria control it involves making known the cause of the disease, its prevention, and cure. The mere act of placing a quantity of information in such places that it is available to the people is probably theoretical publicity, but it is not effective publicity. To be effective the publicity given any subject must be presented in such a way that it is noticed, assimilated, digested, and made a part of the everyday knowledge of the people. In order to get effective publicity the person in charge of the campaign must know the people whom he has to reach. That is, in my opinion, the first step in any publicity campaign. No two communities have the same local problems or interests, no two can do effective malaria control by identical measures, and also no two can be reached by identical publicity. Once the people have been studied, their problems analyzed, and their interests learned, a method of publicity may be worked out founded on their interests, as the mind is more open and easily approached from that angle, and applied to their individual problem in such a way as to make them feel that it is their own campaign.

Originality in publicity is very much sought after. The most frequent result of the search is the production of some entirely meaningless thing, striking in itself, but of no value in advertising the subject matter. Let the same amount of originality be exerted first in studying the people to be reached, learning their point of view; then in finding and presenting in usable form, the connection between this and malaria control; and there results original publicity material which will demand attention. It is the same idea as finding a man's hobby and then riding it with him and selling your line from that angle. For instance, a golf club in Virginia did about \$2,000 worth of excellent *Anopheles* control work after being approached from the standpoint of the mosquito nuisance on the course and at the club house.

Starting with the assumption that the people know nothing of the cause of the disease, and in most cases this is true, give them the whole story in terms that they can easily understand, in fre-

quent bits, only a little at a time so that each part may be thoroughly understood. A common error in publicity is the use of too much material at one time. The human mind can only take in and digest so much at a time and to go beyond that limit is to practically defeat the aim of the advertisement. Frequently—because it is not a subject which commands intense interest from its first mention—there is too long a history of similar conditions lived through and too strong a conviction of the inevitableness of chills in swampy regions for that. Give them something which they see is actually connected with their own everyday life and then there is a foundation for some real work, effective work, in malaria control.

It is better to tell something which the people already know as a starter than to give the reader something which his previous information does not lead him easily to understand. As an instance, I was riding on a train one day with Dr. Griffiths and listening to his talk with a fellow traveler, who, I knew, occupied a position of some merit in his community. The conversation turned to mosquitoes and presently the man asked, "What sort of an insect lays mosquitoes, anyhow?" It required considerable explanation to convince him that mosquitoes themselves lay the eggs from which other mosquitoes develop, as he was thoroughly under the impression that they were laid by a bigger insect, such as a dragon fly. Now, if the publicity campaign in that man's town had been complete he should have known the life cycle of a mosquito. Instead, while he knew that malaria work was being done in town, it was only in a general way that he knew it. A good publicity campaign would have told him, a little at a time, what was being done and what he could do to help. The idea of giving the people something to do to help is one of the best methods known to stimulate interest.

Effective publicity is, in fact, the preparation, the stimulation, and the history of malaria control in any community, and to fulfill its mission it must be based on the habits and interests of that community. It must teach the people that malaria is not a necessary evil in their community and that the spring and fall "course of medicine" is not an absolute requirement for health; how mosquitoes breed, and eliminate the idea so strongly held that mosquitoes breed in pea vines and similar places; that malaria is transmitted only by the mosquito and is not caused by bathing in the middle of the day, although an attack may be brought on in that way, provided the infection already exists; and finally it must bring the individual to the place where he knows, believes, and practices such control measures as are possible on his own premises, for if he does not he is sure to have mosquitoes all summer, will more than likely be unwilling to admit that the work has been of any value, and is certain to oppose any appropriation for maintenance.

This can only be brought about by a study of the special problems in any particular community, followed by a constant application of local conditions to the work of malaria control, and underlaid by a real personal interest in the welfare of the community.

DISCUSSION.

MR. LE PRINCE. I have felt that in Texas the work developed very rapidly and that the influence of considerable publicity that has been carried on there for several years can be noticed over a good section of that State, and I believe a considerable portion of that publicity has been done by Mr. Van Hovenberg. I am going to call on him and ask him to give us a few pointers regarding publicity. A lot of us have to prepare articles for publication, and if we can get a skeleton of useful information in preparing our data for the papers I think it will be worth while.

MR. VAN HOVENBERG. My answer would be to distribute widely Dr. Carter's Catechism. This pamphlet entitled, "Malaria, Its Cause and Prevention," is known as Supplement No. 18 to the Public Health Reports, July 17, 1914. This bulletin may be partly rewritten or issued to newspapers in the form as it is now. Newspapers will be glad to carry this matter daily or weekly. The next medium that I would suggest is the semiweekly farm newspapers or farmers' magazines. The editors of such publications are always looking for scientific material of interest to their readers. If possible, furnish articles to the newspaper men, together with pictures illustrating the contents of the article. These pictures need not be gotten up in as elaborate form as we find in the Sunday supplements, but may be just a column wide. These cuts cost little to have made and can be reproduced from photographs we now have. I believe Mr. Parker has developed one of the most unique ways of advertising malaria control that I know of. This consists of asking the daily newspapers to include with paid advertisements a brief sentence as follows: "Mosquitoes breed in water." "I believe in malaria control," etc.

MR. PARKER can tell you more fully about his methods and I will ask him to take the floor.

MR. PARKER. It occurred to me that it was much better to advertise in short sentences some facts about mosquitoes and malaria rather than put lengthy articles in the papers. When they read the first few lines they decide they know all about mosquitoes and quit. I took the matter up with the merchants of one town who carried advertisements in the paper, and requested them to instruct the newspaper to insert in their advertisement such short sentences as, "Mosquitoes breed in water"; "Mosquitoes are the hosts through which chills and fever are transmitted"; "Mosquitoes breed in water

only"; "Get rid of mosquitoes"; "We believe in fighting malaria; do you?" Just one line was used at the bottom of each "ad," because most of the country papers are devoted a great deal to advertising and the people were sure to read them.

Something of three lines can be written, little squibs regarding mosquitoes or malaria, and scattered in different parts of the paper. The short sentence, "Cut your weeds," appearing throughout the paper, started a program of weed cutting in the town, and in a very short time a great many people were cutting weeds.

Dr. FRICKS. I don't want you to think I am throwing cold water on any legitimate program for advertising malaria control, but I want to remind you that in our original cooperative agreement for malaria control there is a paragraph in regard to publicity coming through the State health officer. I am in favor of publicity, I want you to get it in every legitimate way you can, but the Public Health Service is handicapped in this respect and can not enter into an extensive campaign of publicity, and we have entered into an agreement with the cooperative agencies as to the method of publicity.

Mr. LE PRINCE. As I understand, outside advertising that met with the approval of the State board of health would be satisfactory?

Dr. FRICKS. Absolutely.

Dr. HARRISON. I should like to state, speaking for the State board of health of Texas, that it did unquestionably meet with the approval of the State board of health.

Mr. OLD. At Thomasville we had some little handbills made up, such as this, and had them distributed in the houses.

I had a little experience with moving-picture houses in three towns worked in Georgia. I got up little slides on malaria and they ran them for about a week and then stopped. Sometimes they would only leave them on for half a second and you couldn't read them at all; presumably because they weren't paid for it. I wonder if any others present had any experience along that line.

Mr. SHAW. It appears to me that publicity in our work has two phases; the preliminary publicity for educational purposes and to arouse the people's interest in malaria control generally, and the publicity during operations to secure cooperation and to advise the people of the progress and results accomplished. I think it is a mistake for the engineer to enter a town where no publicity has been conducted, for the people in general are not familiar with the facts concerning malaria, and are not aware of the plan of conducting the malaria demonstrations.

Generally speaking engineers are not inclined to publicity work and they are probably as deficient in this as they are notably deficient in public speaking. For this reason all publicity, press articles, and

papers for educational work, so far as possible, should be centralized in the State board of health or one of the other cooperating agencies, and prepared in such a way as would make them suitable for the entire South. Let the preliminary publicity and papers for educational work include articles on "The history of malaria investigation," "Malaria, its cause and effect," "Habits of mosquitoes," "Malaria control demonstrations prior to the World War," "Army cantonment control and the results," and "Demonstrations since the World War." The preliminary publicity should be accomplished in advance of the initial survey and thus pave the way for the field engineer.

Since the State boards take the initiative in arranging for demonstrations and the demonstrations must ultimately be conducted by them, this publicity should be issued from their offices.

Mr. FUCHS. Mr. Chairman, I would like to mention a scheme of publicity which may not bring immediate results, just as Mr. Van Hovenberg's educational campaign among children may not, but which will eventually bring results when these children have grown up to be citizens.

What I have in mind is an educational campaign in the form of a contest carried on by the North Carolina Land Owners' Association. They obtained through the Surgeon General and the State board of health about 30,000 copies of Dr. Carter's Catechism on Malaria; they distributed them all over the eastern section of North Carolina, where malaria exists, among the children in the schools. Contests were carried on in each school, in each town, in each county, and then in the State as a whole. The children were asked to submit essays on the subject of malaria after they had become acquainted with the catechism, with the aid of the teacher, and these essays were judged locally. The best ones were sent on to be judged by the county officials; the best of these in turn were sent on to a committee, among which was the State health officer, for the State contest. Local prizes, as well as State prizes, were offered.

Now, what was the effect of these contests? They not only brought the study of malaria control to the attention of the children, but each child in writing a composition on malaria, took it home and talked about it with daddy and mother, and everybody in the family was discussing the question. As I say, we have, perhaps, not seen immediate results from this campaign, but I have no doubt that its fruits will ripen with time.

Mr. PARKER. Mr. Chairman, I want to bring up the school proposition again because of a request that came to the State board of health from the principal of a school in a rural community. He advised us not to go down there because if we did the people would

be so antagonized we couldn't get anywhere; that he wanted some literature so that he could educate the children and the people in that community regarding malaria control.

I want to mention Mr. Van Hovenberg's exhibit car. In the town of Alto they had taken up the study of malaria, using Dr. Carter's handbook, in their science class. Mr. Van Hovenberg's car was in that town and the exhibit was shown in the schoolhouse. There was a great deal of enthusiasm demonstrated by the different pupils, and a great many questions asked. I found out later they had been advised that on their examination papers would appear certain questions pertaining to the work that was being done in their town to control malaria; that they would be required to write certain articles pertaining to mosquitoes, their life cycle, and so on.

Mr. JOHNSON. In two of the towns in Alabama the school children from the fourth to the seventh grade studied the malaria primer and were given examinations on it at the end of the year. I looked over the papers together with the principal and I was very greatly surprised to see how much they absorbed. As a matter of fact, they had seen some points in that primer that I hadn't.

In one of those towns they didn't hire any oiler or any inspector during the season. The school principal drew a line through the middle part of the town and they had one group of school children doing the oiling and inspecting on one side of the town and another on the other side, and they had a prize for the group that did the best work. I spent two days in the town and couldn't find a larva or mosquito there.

My experience with movie slides has been very satisfactory. The theater manager in one of my towns was greatly interested in the work and showed the slides at the most advantageous time.

We were greatly bothered at one time by a tremendous rush of *Culex*. There were more tin cans in Demopolis than I ever saw in my life. It was perfectly obvious they were coming from those tin cans. We hardly knew how to get the people in the town interested. I talked the matter over with a newspaper man and a movie man and they suggested that we just run a lead in the movies in good, big letters, "Punch the can." We showed that slide in the theater about a quarter of 9, and at 9 o'clock the next morning we had about a hundred boys lined up in front waiting for their punches. If they didn't get all the cans, I don't know where they were; I couldn't find any that were not riddled.

Mr. LE PRINCE. There will be no further discussion. I am going to call this meeting adjourned until 1 minute of 8 to-morrow morning. We expect a full attendance.

There will be another meeting to-night at the Architects' Club. A moving picture on mosquito control is to be shown, and you will find

it a most interesting one. Also a paper on mosquito control will be read at this evening's meeting. I suppose you have all seen the program. I think it starts at 8 o'clock. The Architects and Engineers' Club of this city have invited us to come and I think we ought to show up 100 per cent strong in courtesy to them. They have loaned us this room, and I am sure we all appreciate it. You will show whether you do or not by your presence this evening.

Evening Session, November 16, 1920.

Members of the Antimalaria Conference met with the Engineers and Architects' Club of Louisville at 8 p. m. in the rooms of the Club.

In addition to other transactions, a paper on "Engineers and malaria control" was read by Mr. W. G. Stromquist. The paper was followed by a moving picture film entitled "Bit by Amos Quito."

ENGINEERS AND MALARIA CONTROL.

W. G. STROMQUIST,

Associate Sanitary Engineer, United States Public Health Service.

From the ancient days of the doctor with his leeches and mysterious herbs, all health work has been considered as being solely within the province of the medical profession. This was a natural consequence of the lack of regard for development of sanitation, and because medical science was limited to the curing of human ills. It is only in recent years that preventive medicine and sanitation have become highly developed. To-day we know that there are many diseases which can be controlled, and greater effort is expended than ever before to keep people well, instead of waiting to cure them after they become sick.

The engineer has played an important part in this work, far more so than is generally recognized. Water purification and sewage disposal, which have been effective in greatly reducing the death rates from typhoid fever, have been developed and recognized by the engineers as their problems. The rôle of the engineer in the control of yellow fever and malaria is not so well known.

The first yellow-fever-control work was begun by Col. Gorgas in Habana in March, 1901. After the campaign was well organized the antimalaria work was begun. Col. Gorgas's right-hand man in direct charge of control work at Habana and later in Panama was an engineer, Mr. J. A. Le Prince.

When the work was undertaken in Habana, it had been proven that a certain mosquito, *Aedes calopus*, was the only transmitting agent of yellow fever, and that the Anopheline mosquitoes carried malaria. The habits of the mosquitoes were not known, and when it was proposed to control these diseases by mosquito eradication the idea was ridiculed on all sides. The courage of these men in attempting the work without precedent or previous experience, in the face of innumerable obstacles, and the effective manner in which the campaigns were conducted, are worthy of our greatest admiration.

The engineer on this work had presented to him a variety of problems such as the habits and characteristics of the mosquitoes in regard to their breeding, resting places, flight, food, etc.; methods of control of their breeding places by drainage, oiling, larvicides, use of natural enemies of the mosquito; the protection against mosquitoes

by screening and the destruction of adult mosquitoes. Coincident with wrestling with these problems it was necessary to develop and direct an organization for conducting the campaign. Immediate results were demanded and had to be produced while the methods were being developed. This required engineering ability of the highest order. Without it the Panama Canal would not be in operation to-day.

The first malaria-control work attempted in the United States was at Fayetteville, N. C., in 1913, as a result of recommendations made by Asst. Surg. Gen. H. R. Carter, of the Public Health Service. During the winter of 1913-14 the Roanoke Mills at Roanoke Rapids, N. C., started work for mosquito eradication to protect their employees from malaria. Similar work was begun at Electric Mills, Miss., in 1914, and also by the Pittsburg Plate Glass Co. at Crystal City, Mo. This was the pioneer work in the United States and was conducted under the supervision of the Public Health Service.

To study methods of malaria control, their relative values and costs, the Arkansas State Board of Health, International Health Board, and Public Health Service in 1916 inaugurated demonstrations at Crossett and Lake Village, Ark., which have been continued and extended to other communities in that State.

Investigations were made at different places to determine the effect of impounded waters upon the prevalence of malaria in the adjacent territory.

In 1916 two engineers, Charles Saville and H. W. Van Hovenberg, conducted an antimalaria campaign at Dallas, Tex., which proved so successful that the work has been given a permanent place in the activities of the city health department.

But considering the great need for malaria control and the vast field open for it, comparatively little was done during the period of 1913 to 1917. However, a small group of earnest workers were laying the foundation, accumulating data, and gaining experience, which in a crisis proved to be of inestimable value. In this work an engineer had an important part.

The crisis came when we entered the great war and many of our training camps and war industries were located in malarious regions. Thousands of men from places free from malaria were placed with infected men, where numerous Anopheline mosquitoes were present to spread the infection. The results would have been disastrous without malaria control, immediate, effective, and on a big scale. The work was done mainly by engineers, to most of whom it was a new problem; yet they accomplished splendid results.

In the cantonments the control measures were directed by the Sanitary Corps; in the extra-cantonment areas—the civilian territory surrounding the training camps—and at various war industries, by

the Public Health Service cooperating with the State and local health authorities. The total area controlled under the supervision of the Public Health Service was more than 1,200 square miles.

The results of this work are indicated in the report of the Surgeon General of the Army, when he states that among a total of $3\frac{1}{2}$ million men there were 14,000 cases of malaria, with 31 deaths. Had the same rate prevailed as in the Spanish-American War there would have been 1,900,000 cases and 5,600 deaths. Records are not available to show the effect among the civilian population affected, but statements of physicians practicing in these areas indicate reductions of from 75 to 95 per cent.

During the past year the International Health Board and the Public Health Service, cooperating with the boards of health of 11 States, have conducted a series of demonstrations of malaria control by mosquito eradication. One or more units of two to four towns have been established in each of the 11 States, with a sanitary engineer in charge of each unit. Very satisfactory results have been obtained as regards the control of the malaria-carrying mosquitoes. Complete data to show the reduction in malaria are not yet at hand, but there is no doubt that a very marked reduction has been effected in all the communities where the work was done. The cost has averaged 74 cents per capita and \$1.26 per acre. This is very reasonable and economically feasible when it has been shown that some sections of the South pay an annual malaria tax of over \$12 per acre in doctor bills, loss of wages and crops, etc. In one of the demonstration areas reports from less than one-half of the families of the community showed that in 1919 malaria had cost these families \$3,300 in doctor bills, medicine, and loss of wages. The cost of the anti-malaria campaign in 1920 was \$1,800. The comfort of being practically free from the mosquito pest has been an important factor in making the work popular with the public. The ultimate purpose of these demonstrations is the development of State and local health organizations to direct and extend the work.

Malaria is being recognized as a business proposition. Since 1917 the St. Louis Southwestern Railroad has employed a sanitary engineer to direct antimalaria work among its employees and in towns along its lines. The results have been reduced sickness and increased efficiency of employees and greater production in the tributary industries, with more revenue for the railroad. One lumber mill showed an increase of 20 per cent in its production as a result of the first season's work, which added \$60,000 to the railroad's freight revenue. The officials of the road have been so favorably impressed that the work has been expanded and other sanitary work included, so that all-year positions can be offered and a permanent organization be maintained under the direction of an engineer.

This paper is not an attempt at a history of malaria control, but an outline of its development has been given to indicate the part played by the engineer.

Malaria control offers splendid opportunities for the engineer. The problems of drainage, oiling, and other methods of mosquito control are his problems. There is yet much to be learned, and a need for development of more economical methods. Malaria control is needed over a territory of 400,000 square miles, with a population of over 10,000,000. The problem presents economical, social, and educational features. Its solution will require careful planning and efficient organization. The need for effective and economical work, the opportunities for great service to humanity are such as to appeal to the highest instincts of an engineer.

Malaria presents a problem not only to the sanitary engineer directly concerned with its control, but also to every engineer and architect in a malarious community. Most directly it affects the health of himself and his family. An engineer on a railroad survey party, a drainage or water-power development project, a mill superintendent, or a man in any branch of engineering in the South is constantly confronted with the question of malaria control. He must produce maximum results at a minimum cost. Efficiency and malaria can not exist together. The engineer must realize that he has been responsible for an increase in malaria in many localities—what Dr. Carter calls “man-made” malaria. Undrained borrow pits on railroads and highways, culverts placed too high so that a pool forms on the upper side of the embankment, impounding reservoirs—all of these afford ideal breeding places for *Anopheles*, and in many places have caused an increase in this scourge of the South.

Malaria is the greatest problem of the South to-day. It causes an annual loss which has been estimated at more than a billion dollars and human suffering which can not be estimated. A child infected with malaria can not get the physical and mental development which is its right. From such we can not expect the highest type of citizenship. A man who has malaria is at times only one-half a man or no man at all. A community where malaria is prevalent can not be progressive and prosperous.

The South has vast resources which are yet untouched. The greatest retarding influence is malaria, which must be eliminated before these resources can be fully developed. The engineer must lead in the fight.

Morning Session, November 17, 1920.

The conference was called to order at 8 o'clock by Mr. Le Prince.

MR. LE PRINCE. The first paper on the program this morning is “Transportation,” by J. C. Carter.

TRANSPORTATION.

J. C. CARTER,

Assistant Sanitary Engineer, United States Public Health Service.

Transportation is one of the items of expense in connection with an antimalaria campaign, and is a subject which deserves much consideration.

As transportation costs are influenced by a wide range of conditions it is impracticable to erect definite detailed policies which will be applicable in each community; therefore the suggestions in this paper are general and are to be taken as such.

In discussing this subject two distinct items must be considered: First, transportation of the engineer or supervising officer; secondly, transportation of labor, materials, etc.

The former assumes greater proportions, as the traveling expense of the engineer continues throughout the year, while that of labor and materials exists only during the time of actual operations.

It has been my experience that during the time of actual operations a light automobile can be used by the field director to great advantage, provided the communities are situated within short distances of one another. Road conditions must also be taken into consideration.

One great advantage of travel by automobile is the elimination of delays caused by waiting for trains and train connections. This is especially important where an inexperienced local foreman or inspector is supervising the work, as is often the case. Here is an instance of time saving by the use of an automobile. Two towns in which I directed campaigns during the past season were 60 miles apart and were not directly connected by rail. The trip from the one to the other could be made in an automobile in about two and one-half hours' running time, whereas the trip by rail consumed one-half a working day with a night en route and its attendant expense.

The engineer will also find the automobile an advantage in covering the area under control within the various communities under his direction. This saves much time and insures an intelligent and efficient supervision.

An automobile for the use of the engineer may possibly be obtained from the State board of health, the United States Public Health Service, or by the engineer buying his own car, in which

case the health agencies should pay the running expenses and a reasonable amount each month for depreciation.

During the time of making surveys the engineer as a rule is not so pressed for time that the waiting on train connections will be a serious handicap. Also in many sections of the malaria country the roads in the winter are very poor and at times impassible. Travel by automobile under these conditions is always expensive and uncomfortable, which makes travel by rail at this season of the year preferable.

The transportation of labor and materials is not so great a problem. The municipalities usually have motor-driven or animal-drawn vehicles which can be secured at intervals without the expenditure of malaria funds. Public-spirited citizens also may at times donate the use of trucks or wagons.

The oil company from which the oil is bought will deliver it in barrel lots to designated places within the oiler's zone from which he can work his entire area. Small two-wheeled pushcarts may be used to advantage by the oiler to transport oil from distributing stations to the area under his control.

Railroads will frequently haul materials from one station to another without charge. Motor cars may also be secured from them, but the area which they will serve is naturally limited.

Transportation of labor may be reduced or eliminated by providing a place for the storing of tools and equipment at or near the point of operations and instructing the men to report there at work time, rather than have them meet at some other location, gather their tools, and be transported to work.

DISCUSSION.

MR. LE PRINCE. Most of those who are here know that according to Government regulations, probably adopted before the automobile came into existence, we are allowed to pay for transportation anything up to \$10 a day. We haven't the money to pay for a machine. We can not hire a machine by the month or by the season, and some very definite conclusions ought to be arrived at, this morning, and possibly some representations made to the State boards of health so that they can make arrangements with the localities selected. That should be done before the places where we are to work next year are agreed upon. We must have transportation. We would like some remarks and suggestions for improving the present conditions.

MR. JOHNSON. I had an experience somewhat like Mr. Carter's, in the same State but in another section. I had two towns 18 miles apart by road, with a pretty fair road between them, not more than

an hour by road. If I went by train I was forced to go away back to another point, stay there all night, and get out the next morning, and not only had to lose that day but had to run a hundred miles by railroad. There is not just one place like that in Alabama; there are dozens of them. I think that we can not get anything that will help out malaria work in Alabama more than adequate transportation by automobile. Like Mr. Carter, I don't know where it is coming from, but it has got to come from somewhere if we are going to handle that work successfully.

In making preliminary surveys I have found that you can get local transportation. I had one county in which I made 10 surveys about two weeks ago. All the car fare expense was from Montgomery to the county and back. In every town I went into I got a local physician interested and got him to take me all over the whole town in his automobile and drive me on to the next town.

MR. LE PRINCE. I want to ask, Mr. Johnson, whether you were given transportation during the malaria season.

MR. JOHNSON. I wasn't given much transportation during the working season. When you go into a town on one visit on a preliminary survey you can almost always get an automobile, but when you go back often during the working season the physician isn't going to take you around; he hasn't got the time.

MR. LE PRINCE. I want to hear from some one here who has actually got transportation during the working season.

MR. DAVIS. The city authorities in Savannah, Ga., before we started work there, agreed to furnish transportation, which they did from the time of my going there until the end of the season, at the expense of the city alone.

MR. LE PRINCE. Has anybody working in several units been able to have a car from one unit to the other during the summer time?

MR. ROPES. I have had some success in Malvern in getting free transportation. The inspector we had was connected with the water-works and he took me around in his Ford car, the cost of which was paid by the city. In some of the other towns I think Mr. Hastings had an arrangement with one of his inspectors by which he got the use of an automobile at a nominal cost. I have also had some success, like Mr. Johnson, in getting some physician to carry me around, sometimes in the town itself, or sometimes from town to town.

MR. LE PRINCE. I have been in Mr. Hardenburg's district in Texas, and I found that all the train connections were between 2 and 4 in the morning—perfectly delightful. I went without sleep to make those connections. Now, he made his arrangements with the four towns, I believe, in such manner that each one of the towns paid for one-quarter of the total automobile bill for the season. That is a

point which the State board of health should take up and should make arrangements along those lines. If it could be done in Texas it may be done at other places, but I don't think we should operate in units where we have not proper transportation.

I think the average field director would accomplish 50 per cent more work if he had proper transportation.

Mr. KOMP. Just to show what a difference transportation may make in the results of a mosquito campaign; in one of my towns I had a service car that I managed to get from Gulfport, for which the town provided the entire upkeep. In the other town I had no means of transportation. In the first town we had no mosquitoes; in the second we did. I think my experience is typical, and answers the problem right there.

Mr. PARKER. In my unit, for two or three months I was without any transportation whatsoever except the railroad. The trains run so that if I want to get into a town it means that I have to spend all day in that town, even if I only had an hour's work to do. That was true in all the towns. My unit averaged about 8 miles in length. The roads were fairly good and jitneys could be used to go between towns, which cost on an average about \$5 to \$7 a trip. On a bad day, or if the weather threatened, you couldn't get any transportation. I soon realized that if transportation other than the railroad wasn't obtained in that unit the work wasn't going to be a success, so I bought a car.

There has been an appreciable reduction in malaria, and the only reason I can give for this, outside of the cooperation of the people, is the fact that I provided myself with an automobile. It was particularly necessary to have quick transportation toward the end of the season, when I was having a great deal of trouble keeping labor. This meant that I had to be in two towns during the same day, and especially on Saturday, which was pay day. If I didn't get into those towns, I lost my labor. It took two days by railroad to do what I could do in three hours with an automobile, and I don't think under those conditions the transportation could be curtailed.

Mr. WOODFALL. Mr. Chairman, I was in the Public Health Service for two years, and I fought for this thing from the time I entered to the time I left the service, and finally concluded by walking over 50 per cent of the time. At present I am with the State board of health in Georgia and I still have to walk. During my work on malaria I had to walk from one town to another and look mournfully at every automobile that passed me, hoping that I might be asked to ride, but I found it never worked.

Mr. Old was in a small town in southern Georgia and had to wait about six hours for a train to return to his headquarters. Rather than wait he walked the 11 miles, and he told me that 18 or 20 cars

passed him and none invited him to ride. We attribute this fact, however, to his looking more like a hobo than an engineer.

I doubt very much whether the State board of health of Georgia in the year 1921 will have much more money for carrying on malaria work than they have to-day. It is at this time as never before that the southern health departments need the cooperation and help of the United States Public Health Service and the International Health Board.

I realize the need of transportation for the service engineers on malaria work, but under conditions of to-day it is impossible for the Georgia State board of health to furnish men in the field with automobile transportation. We hope that this may be corrected in the future and that some provision may be made whereby transportation may be furnished these engineers.

MR. LE PRINCE. In connection with this work of malaria control the press should be considered, and possibly some of the State health departments, by interesting other persons, can bring this matter to the public attention so that we can get a proper sentiment built up.

You may not have read the Mississippi statistics of malaria. Those of you who have not done so should, and from the State health officer of Mississippi you can get some very useful working figures. Now, there is transportation for malaria, but it is from the town to the cemetery and back. That is the only fixed transportation that I know of. That transportation involves in that one State 1,000 deaths every year, largely of little children, and if we make these facts known it will help us in this fight. You know there are several hundred cases of malaria to a death, and I want to see that transportation changed from the hearse to the Ford for the engineer.

MR. VAN HOVENBERG. Mr. Chairman, I believe we are all here of one mind on the question of transportation. I take issue with Mr. Parker privately on some of the things he said about Texas, but I believe that we all feel that it should be incumbent on the State health department to provide transportation for the man in the field. I move that this sentiment be expressed by resolution as follows:

That this body of sanitary engineers and others engaged in malaria work in the field go on record as asking the State health departments to provide transportation, as they see best, in the various States in which they are engaged.

MR. LE PRINCE. You have heard the motion, gentlemen. Is there any second to that?

DR. BARBER. Seconded.

MR. STROMQUIST. Let me interrupt a minute. I would like to add to that, with Mr. Van Hovenberg's approval, "We think that it is extremely important for their success in carrying on the work."

Mr. LE PRINCE. You have heard the motion. All in favor of that will please rise. The motion is carried unanimously. In this connection, I wish to refer to the remarks made by Mr. DeMott, who has eight machines—it is a case of one man not only handling a county, but handling a county in a most satisfactory way. But he tells us that the automobile is the answer of one man handling a big territory. How can we get the State board of health, and the county with the help of the State board of health, to get the money for it?

Mr. FUCHS. In this connection I want to suggest a plan that was proposed by the State health officer of North Carolina when this matter came to a head. He suggests that after the cooperating towns are selected, the cost of buying and maintaining the automobile be apportioned in the same proportion as the funds appropriated for malaria work—by the various towns, the State board of health, and the International Health Board. At the end of the season the automobile would be sold, if the work is not to be continued, and the proceeds returned to the donors in the same proportion. I think that would be the best solution of it, without being a hardship on any one agency. The International Health Board and the State board of health are interested in this work, as well as the towns, and such apportionment of the cost would seem to be the fairest and least burdensome.

Mr. DE MOTT. I will explain how we procured machines for Nassau County. After I was appointed chief engineer I read through the files of the time lost by the men, due to lack of transportation, during the years 1916 and 1917. It amounted to about \$2,500. I presented these facts to the commissioners and told them the county was paying for the men to work, but we did not have proper transportation to put them on the job. The amount of money that the county lost through lack of transportation would pay for three or four automobiles. Immediately the commissioners decided to purchase four automobiles.

Mr. LE PRINCE. Is Dr. Fricks here? I might just summarize what has been stated. It has been resolved here unanimously that arrangements be made by the State health departments to supply automobile transportation in order to double the efficiency of the engineers.

Dr. FRICKS. What is expected of me, Mr. Le Prince, may I ask?

Mr. LE PRINCE. We want you to help us, Doctor, and we want your approval; we thought the resolution was not unanimous without it. And it was also suggested in the general discussion that towns be not accepted unless there was suitable transportation provided, in order that the engineers should not do a 50 per cent job, when it was possible to do a 100 per cent job.

Dr. FRICKS. We all know that this problem of transportation is one of the most difficult ones encountered in carrying on field work,

that if we had adequate transportation in the field, the work would be decreased perhaps 50 per cent in some instances. Certainly 20 per cent is a conservative estimate.

We all know, too, that as far as the Public Health Service is concerned, the matter of transportation is an extremely difficult one to handle. The International Health Board—I am speaking now from a cooperative standpoint—can handle the question of transportation somewhat better, and has in several instances, done so in this work. It seems to be practically impossible for the Public Health Service to furnish adequate transportation for field officers engaged in malaria control investigations under present conditions—the limited size of our allotment and the governmental requirements covering transportation.

What the States can do in relieving this situation, I do not know. I think the resolution submitted is good and hope that it will accomplish something. I have felt that in making preliminary surveys, there ought not to be any need for a field officer incurring expenses for transportation, because the Rotary Club, the city council, or the health officer would be glad to take him around for one day; but I know also that he might easily overstay his welcome, and if he prolonged his visit for a few days and wanted the use of an automobile to make a thorough survey of the town or to supervise the work, it would perhaps be asking too much.

It seems to me that our fundamental idea of tying up with a permanent live local health organization will have a favorable bearing on the matter of transportation. In those towns that are undertaking the work, which have a full-time county or city health officer, transportation will be more easily secured than elsewhere. This seems to me a very excellent reason why communities which have permanent health organizations should be given favorable consideration in selecting a place to work.

Mr. LE PRINCE. Our next paper will be "Oiling and larvicides," by Mr. E. B. Johnson.

I make this statement at this time because you will all be interested and possibly may want to talk it over.

Mr. LE PRINCE. Send in any information regarding drainage methods or short cuts, matters that might be valuable in our drainage work. The idea is to get the information in as early as possible. In that connection, some of you will develop certain things that you think ought to get to all the other coworkers, and this exchange bureau is arranged for that purpose.

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E. B. Johnson, Oiling
& Larvicides.

THE PART BIOLOGY PLAYS IN THE DISSEMINATION OF MALARIA.

BRUCE MAYNE,

Associate Sanitarian, United States Public Health Service.

We have 40 years of accumulated knowledge as the basis for future studies in the parasitology of malarial fever and yet a vast field remains scarcely explored. It is to be lamented that there still exists lack of appreciation of the facts concerning malaria transmission, and for this reason I have taken the liberty of reviewing the subject in a nontechnical style so that its scope may be better interpreted.

Until the true cause of malarial fever was discovered in 1880 numerous theories on the origin of the disease were promulgated by the medical profession. Among these, the most acceptable was that proposed by an Italian scientist who maintained that a germ named *Bacillus malarie*, which was constantly present in the mud of marshes, was the cause of the disease in man. Other theories, half baked and fanciful, were proposed in support of the ancient opinion that bad air and bad water were the natural lurking places for the germs which made the human victim shiver and sweat in the paroxysm of the ague. However wrong these views may seem to us now, we must admit that the haunts in which the disease had its origin were known as well as feared by the ancients and that the Italian name for the disease, malaria (mala-aria—bad air), holds to this day.

Even so recently as 10 years ago certain medical textbooks affirmed, and unthinking physicians even to-day accept the notion that drinking polluted water may give one malarial fever. And despite the advances of scientific medicine certain others are still skeptical that the bite of an infected mosquito is the only way whereby the disease can be propagated. One modern author advances the hypothesis that mosquitoes normally feed on plant juices and infect plants by stinging them with the mouth proboscis in the same manner in which the human blood is infected. It is alleged that such vegetable material eaten uncooked would cause the human host malarial fever through the gastrointestinal tract. The same medical writer believes it possible to contract the disease in two other ways, namely, drinking water in which malaria-infected mosquitoes have laid their eggs and died, and by breathing air laden with the germs malaria-infected mosquitoes have disseminated.

However, these views have been condemned by the careful student of parasitology and the most modern conception of the problem is bound up in the application of experimental proof. It may be pointed out that in contrast to our skeptics in science many wild tribes in tropical countries have long been observed to protect themselves and their live stock against the bites of mosquitoes, for it was a popular belief that these insects were somehow responsible for the propagation of tropical fevers. Yet the scientific world discredited this belief of the uncivilized man until nearly the beginning of the twentieth century, when the combined observations of the founders of modern tropical medicine had established in all its fascinating detail the fact that the mosquito is the constant and necessary vehicle of malarial infection.

Recently, however, medical textbooks are unanimous in accepting the claims of the modern scientist that the microorganisms harbored by certain mosquitoes have been ingested with the blood from an individual sick with malarial fever. This was announced for the first time fully 17 years following the determination of the causative parasite in the human blood. The credit for this important discovery is given to Sir Ronald Ross, a British military surgeon, who in 1898 completed his brilliant researches which demonstrated completely the development of the malaria parasite outside of the body of the human host within the mosquito which perpetuated the disease. Ross was able to follow the cycle within the insect until the parasites harbored were in such a developed form as to be suitable to infect new red blood cells when the mosquito bit another human victim.

Abundant proof of this has been furnished from time to time and ample confirmation of the rôle of the mosquito in malaria dissemination supplied through the medium of experimentation. More than 60 well-authenticated cases of mosquito inoculation of human volunteers have been recorded. Sixteen of these experiments were conducted in the laboratories of the Federal Health Service under the writer's personal supervision, so that the complete story of the part played by the mosquito in the spread of this dread scourge can be told from actual experience.

In order to intelligently appreciate the rôle that the mosquito assumes as a vehicle of destruction it is necessary to describe the condition of the blood in the patient and how he functions as a carrier of these pathogenic organisms. To find these parasites one need only examine the blood of a patient suffering from an acute attack of intermittent fever. This is done by drawing on a glass slide a droplet of blood from a finger or the ear lobe pricked with a surgical needle and examining it by means of a fairly powerful microscope. In this connection, when one views for the first time the germs of the dis-

ease which have invaded the human blood cells he can appreciate the thrill of the scientific voyager and share the prophetic vision of the discoverer, the French army surgeon, Dr. Alfonse Laveran.

It was a memorable day for Dr. Laveran when, in a French Algerian military hospital, examining with unbounded patience the blood of the victims of the dreaded scourge of northern Africa he discovered that the cause of malaria was a living organism which destroyed the red blood corpuscles and transformed their contents into toxic substances, giving rise to the classic symptoms of the disease. He had been perplexed a long while in observing one of the minute Amoebalike specks, which were then believed to be nothing more than degenerated corpuscles, when suddenly the cell projected several long, slender filaments which began to move about very actively, lashing and displacing the surrounding corpuscles. This was accompanied by a peculiar turmoil of the brassy black granules within the cell. Thus was revealed the animate nature of these bodies and was proclaimed the real cause of the febrile disturbance in the patient's blood.

It may be noticed that in an examination of a drop of blood a certain number of the red corpuscles exhibit a tiny whitish form which continually alters its shape very much like a gas flame, which, during a gust of wind, flickers within its glass globe. These movements of the parasite are called amoeboid because they characterize the movements of the Amoeba, the simplest member of the animal world, consisting of a single cell of living protoplasm. And although it has no constant definite shape, the Amoeba in this instance can assume a threadlike fineness and pierce a red blood corpuscle as it migrates, after its function of corpuscle annihilation, from cell to cell in the blood stream. Some hours later the parasite in its metamorphosis will have increased in size elaborating minute brassy black grains called pigment granules, the product of the haemoglobin, the substance contained in the red corpuscles which the parasite is constantly engulfing with its jellylike body. These pigment granules gradually become shifted toward the center and help to give the parasite a daisylike appearance when it has finally broken up into a number of segments. When this rosettelike arrangement is perfected the red blood corpuscle bursts open like a seed pod and the segments, forming new parasites, escape into the blood stream and are able to penetrate new red cells. Thus the life process is repeated and when the new invader has grown to about the size of the corpuscle and exhausted all its foodstuff, the partition of the new organism progresses indefinitely as before.

This cycle of development in the parasitic Amoeba, which has taken place wholly within the body of the human host during 48 to 72 hours, gives rise to definite clinical symptoms of the disease,

and when at least 25,000,000 of these invaders are present a paroxysm of chills and fever results. After two or more of these paroxysms, when several generations have passed during the growth of the invading organisms, an examination of the blood reveals peculiar forms assumed by numbers of the parasites. They appear as blunt-ended crescents with transparent bodies and clumps of black granules in the center. In others, depending on the species of the malaria parasite, these bodies are quite ovoid, resembling the matured forms preceding segmentation. They are now the resting spores or gametes, and, like the spores of the bacteria, are able to survive in a quiescent state the unfavorable conditions of growth in the living medium.

It is now high time for the villain of the tragedy to enter, for it is during this period of passive life that the gametes require some external vehicle for continued development. This is offered in the ideal form by a preying mosquito which, invading the haunts of man at dusk, chances to draw its fill of blood from a parasitized person. It is necessary for the completion of our story that this mosquito be a female belonging to the genus *Anopheles*, with spotted iridescent wings and long delicate palpi. The protozoan malaria organism seems to have a peculiar affinity for insects of this sort, for thus far no other genus has been found capable of cultivating them. The dormant parasite thus enjoying a change of host suddenly awakes to renewed activity, changes its form from crescent to round, throwing out long filaments which leave the body of the cell and are seen to attack organisms of the opposite sex which in natural course of favorable development are penetrated and fertilized. After fertilization within the stomach of the mosquito the new parasite transforms, becoming more elongated. Then acquiring movement, it is enabled with its spiked end to pierce the several stomach linings of the insect, finally lodging on the muscular wall of the organ, assuming a globular shape. It soon becomes encysted, though still able to partake of the generous blood supply that accompanied it when it was taken within the gnat's interior.

The cyst now organized becomes inclosed in a structureless, transparent capsule growing to many times its original size. In a parasitized *Anopheles* the entire stomach wall appears festooned with tremendous numbers of these tumorlike masses of protoplasm which break up into a number of tiny spheres. Minute spiny processes appear on these segmented spheres which, growing longer, separate from their attached cells, appearing as prickly filaments within a sac. Then the membranous sac or capsule bursts and these filamentous, spindle-shaped organisms, the sporozoites, stream forth like a school of tadpoles into the body cavity of the mosquito. It is now a speculation as to the behavior of these bodies, but we know that some-

how the sporozoites are carried by the body juices of the insect to its salivary glands, where they establish themselves, mixing with the saliva of the insect host. When the mosquito bites a healthy person it injects with its saliva a great number of these very active new parasites, the sporozoites, which are introduced to begin again the rejuvenated, endless cycle. These sharp-ended bits of protoplasm begin the struggle by first penetrating red-blood cells, doubling end to end, shaping themselves into rings, each of which develops rapidly into a jellylike Amœba, the shapeless, active form in which it entered its parasitic career within the blood of the human host.

Thus we have rehearsed a typical biological cycle of 10 days with stages of growth characteristic of a disease-producing parasite.

It would be logical at this juncture to discuss some of the essential factors which retard or accelerate this biological development. And the first that comes to mind, the most influential in the life of any organism, is the factor of temperature. Temperature has both an internal and external influence in association with parasitic life in the mosquito. There is a period which is critical during the time of the fertilization of the human blood parasite in the mosquito's stomach, for it has been learned that this process does not take place if the temperature falls below 60° F. Even should fertilization be successful, the temperature conditions must be favorable until the time of the development of the forms which, after leaving the stomach wall, lodge in the salivary glands and escape through the suctorial mouth.

It is on this account that the malaria organisms are killed off during the cold days of winter; and although the mosquito lives in a dormant stage, it emerges from its sleep as innocent of carrying disease germs as though it had just emerged from its watery cradle in a preceding stage of life. We must note in passing that it is "man's inhumanity to man" that is alone responsible for perpetuating the disease during the hibernating period, for he is the true winter carrier of malaria parasites; and the finger of scorn must be withheld from the mosquito until the warm days of spring make her again culpable.

To interpret the full significance of the insect's rôle as a disease carrier, let us get an insight into its power in ways pathological. How many persons can a single mosquito infect and how many germs is it necessary to inject into one's blood to convey the disease of malaria? Also with the same breath we inquire, How long will a mosquito once infected with these germs remain so? Now, it may be interesting to observe that up to three years ago the conscientious investigator could honestly shrug his shoulders and throw off the burden with "I'm sure I don't know," but to-day certain researches have brought to light at least approximate answers to these riddles.

Indeed, all of these points have been investigated, and though not completely solved, have shed rays of hope on prospective researches. Since these queries are concerned intimately with the operation of biting, we can judge more clearly by reviewing briefly the method involved. If one is sufficiently curious and interested and will permit a hungry (though healthy) mosquito to alight on the back of the hand he can learn enough at one application to be quite convinced. With the aid of a hand lens if one observe the actual blood sucking after the preliminary selection of site for the drilling, it will be apparent that an appreciable time elapses from insertion of the mosquito's beak to the appearance of the drawn blood as it rises in the alimentary tube. The phenomenon is appreciated by the careful surgeon who reverses the operation when in injecting a fluid into the patient's vein he plays safety first, insuring the needle's position by drawing some of the blood into the barrel of the syringe before pressing down the plunger and releasing the contents.

In the first few seconds of biting really all of the mischief is done both as to physical damage to the feelings of the host and the inoculating of the infecting organisms, for it has been proved that mosquitoes inject their poison before commencing to suck blood. This is accomplished by the insect, which in attempting to lubricate the mouth parts in "clearing for action," deposits its saliva in which are mixed the virulent organisms. Then whether it gets its meal or not, if interrupted at this stage, it has already accomplished its function as a disease bearer by introducing the poisonous fluid into the wound. The pumping of the blood to satisfy the mosquito's nutritive demands is therefore incidental. At any rate, it has been actually proved that when mosquitoes were allowed to bite two volunteers for periods of 35 seconds and 50 seconds, respectively, illness resulted in both instances, demonstrating beyond a doubt that virulent parasites had been introduced in these short, interrupted bites. In the same series of experiments it was demonstrated that several persons, at least three, could be successively infected from the bites of a single mosquito.

Relative to the length of time mosquitoes remain infected, it must first be ascertained what is the life of a mosquito. This having been recently determined in our Memphis laboratory to be as long as 185 days, should it prove to be true that an *Anopheles* mosquito can remain infected as long as it lives it will contribute to our knowledge in attempting to explain certain mysteries of no inconsiderable sanitary importance. So far, however, experimenters have not been able to cultivate in their laboratories mosquitoes which can communicate the malaria disease germs beyond 60 days, and although organisms may be present for four months they appear to be without life.

In our review of the mode of carriage of a menacing insect-borne disease, we have found that a mere trifle—"a trifle as light as air"—has been the cause of it all. It is asserted that man digs his grave with his teeth; it is far more certain that the mosquito's teeth have dug many a grave. And the victory of science in drawing the teeth of the vicious mosquito has blazed the way for scientific control of sanitation and health, and has made possible such achievements as the domination of the white man in the Tropics.

At this juncture it may be an aid to speculate on the bench problems in malaria epidemiology, unsolved and most desirable of solution. This being a practical dollar and doughnut world, the modern biologist is no longer an academical research theorist, but must be primarily a sanitarian—a 100 cents on the dollar sanitarian. Therefore we are prompted to indicate at least some of the more interesting if not more vital questions upon which more light is required. A mere mention of these is all that is necessary.

PROPOSED INVESTIGATIONS.

1. Would the destruction of all forms of mosquitoes in a region during the winter insure immunity to malaria the following season?

2. Do mosquitoes infected in the late fall rid themselves of malaria parasites during the winter months by attacking live stock housed in warm stables?

3. How late in the season does the mosquito cease to be a menace in malaria transmission?

(When to discontinue oiling and lay aside precautionary measures.)

4. How early in the spring does the mosquito become effective as a carrier of malaria?

(When to begin oiling and screening, and if desirable to consider quinine prophylaxis.)

5. The length of time an Anopheline mosquito once infected remains so.

This question is in my opinion one of the most vital and incidentally one the solution of which is greatly sought by investigators the world over.

6. How soon after draining an area of land does the aquatic life of *Anopheles* become extinct? Do mosquitoes in the young stage survive drying out or thrive in semidried mud? Can eggs of *Anopheles* survive dessication?

7. Mosquito predilection for food—Can domestic animals be utilized to attract mosquitoes away from the domiciles of man?

(Can live stock be used practically to establish a barrier in the nature of bait between areas of mosquito propagation and human habitation?)

8. A satisfactory substitute for the much-abused salts of quinine. (Any agent which will accelerate parasite destruction and shorten treatment.)

9. The value of the differential leucocyte count in the diagnosis of malaria in blood examinations.

Such a test might be valuable as an aid in diagnosis particularly in the absence of demonstrable blood parasites. Thus far in a critical study of some 400 positive malaria blood specimens nothing specifically characteristic has been observed.

DISCUSSION.

MR. LÉ PRINCE. The paper is open for discussion. May I ask Dr. Barber to make a few remarks?

DR. BARBER. Mr. Mayne has made clear some very important phases of the problem of malaria. As regards the popular knowledge of malaria, a subject which may more properly belong to the discussion of an earlier paper, I may be permitted one or two observations. In the course of some house-to-house work in Arkansas I have very rarely found people who were not familiar with the fact that malaria is transmitted by mosquitoes. That mosquitoes are the sole vectors of malaria was questioned by a few people, among them one or two health officers, who cited cases of reduction of malaria coincident with improvement in a local water supply. In discussing this matter with them I readily admitted the possibility that any measure which would reduce intestinal disease might reduce malaria morbidity, since such a disease might provoke a latent malarial infection into activity. One would not admit, of course, that water could ever act directly as a vector of malaria.

DR. COOGLE. There is no doubt in my mind that malaria is transmitted to the human being only by mosquitoes. Feasible and practical methods for its control are known; means for its eradication are to be perfected.

Practical methods of eradicating malaria will probably be worked out after the solving of the engineers' and the doctors' problems. Malaria is a man-to-mosquito-to-man disease. The doctor's problem is the man; the engineer's problem is the mosquito. Together, the doctor and the engineer must educate the people to all the known practical methods that will lead to malaria eradication.

Mr. Mayne's paper is an excellent one.

DR. HARRISON. Mr. Chairman, I can not refrain as a physician from expressing my admiration of Mr. Mayne's paper. I have listened to a great many papers on the subject of malaria transmission and this has been an extremely concise and clear-cut explanation of the subject, and I should think that to a body of sanitary engineers

it would be of unusual value. You will often be called upon to give more or less this same explanation to the public, and it seems to me in all public-health work, that before we attempt to disseminate knowledge we should be extremely sure that we are familiar with our subject, and that we are giving to the public facts that can not be questioned. It appears to me that every engineer present would do well to know in the future that he has thoroughly understood this paper, and has gotten all of the points clearly fixed in his mind. It would be a very valuable paper, not only for a body of engineers, but for any body of doctors to have heard and to have gotten thoroughly fixed in their minds. It is a clear-cut explanation of the life cycle of the malaria parasite and the method of transmission of malaria. I may say that a favorite State board examination question for doctors is to describe the life cycle of the malaria parasite.

Mr. FISHER. Mr. Chairman, I wish to make two observations that will probably be of interest in this case.

At Chester, S. C., which is a *punctipennis* country, our census indicated that approximately 7 or 8 per cent of the people there had malaria, which, I think is somewhat interesting in showing to what degree *punctipennis* is an agent in carrying the disease.

The other observation is that at Bamberg through certain circumstances oiling was delayed or discontinued for about two weeks right in the middle of the season, which, of course, released a brood of mosquitoes. They persisted in the community for about three weeks, which gives some idea, I think, of the length of the life of *Anopheles* in nature.

Mr. STROMQUIST. Without the work of a laboratory man the malarial parasite would not have been discovered, and we engineers wouldn't be in this work to-day. Without the work of such men as Mr. Mayne, who are studying different problems and developing these things we wouldn't progress in the work, and it is up to the engineers, who as a profession must use all available means of knowledge to apply practically, to make use of this knowledge that Mr. Mayne and others are developing for us, and it is also up to the doctors to do the same thing.

We find in our work any number of doctors who mention this theory of transmission by mosquitoes. Just a few days ago in Memphis a man brought in a sample of city water to me and wanted an analysis. I asked him if they had any sickness there, and he said two cases of fever. I said, "Typhoid fever?" He replied, "No; malarial fever; and the doctor tells us it is probably due to the water."

Mr. VAN HOVENBERG. In regard to the question of eradicating malaria through the elimination of human carriers, I would suggest that the function of the malaria parasite in man was known to medical

science as early as 1880. With due respect I would say that it is only within the past four years that we have begun to make history in reduction of malaria in the United States, principally through mosquito control. [Applause.]

Mr. LE PRINCE. One point brought out in the discussion is of interest to me—this persistent talk about connection between drinking-water supply and malaria, and I have often wondered if this large increase of screening has been done simultaneously with the improvement of the water supply.

Mr. Mayne will please close the discussion.

Mr. MAYNE. I would like to close my paper, Mr. Le Prince, by showing these photographs.

This first photograph is a graphic reproduction of the life cycle. We will pass that around and see it at close range. It is a little scheme that I sketched to show what takes place in the blood of man and in the mosquito's body.

Some of you may be interested in the different species of the Anopheles. This photograph will show you the difference in the wing structures of the *quadrifasciatus* above, the *crucians* in the middle, and the *punctipennis* at the bottom, and I think if you will look at this your observations in the field will indicate to you the difference very readily. The posture of the mosquito is shown. You will readily recognize the posture of the Culex and the Anopheles.

This is the head of a female showing it in the act of projecting its lancets in biting. This is an enlarged photograph of the salivary glands, through the thorax; you can see the relative position of the salivary glands. Here is the stomach of a mosquito showing the parasites on the stomach wall, which contains bundles of these filamentous parasites. That is another of the same, showing the tremendous multiplication. This is a camera lucida drawing, by the way; each one of those oocysts actually occurred on the stomach wall of the mosquito.

Mr. LE PRINCE. The next paper is "Oil burners as weed killers," by Mr. Shaw.

OIL BURNERS AS WEED KILLERS.

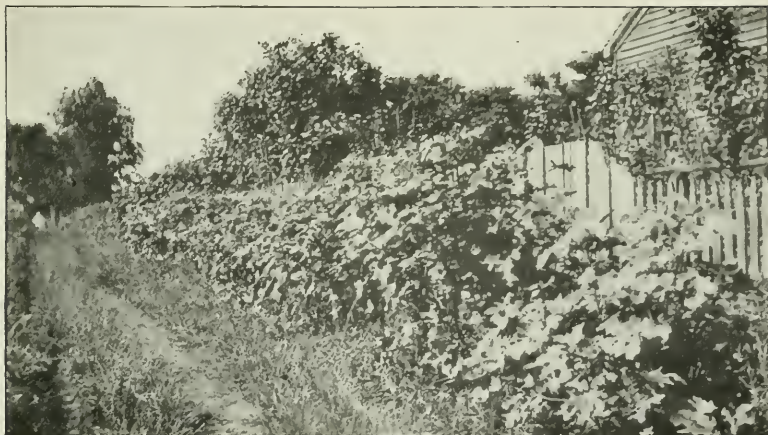
FRANK R. SHAW,

Assistant Sanitary Engineer, United States Public Health Service.

An investigation was made in Baton Rouge, La., to determine the effectiveness and economic efficiency of a standard kerosene burner used in the destruction of vegetation which is found adjacent to water courses. The consideration of effectiveness involves only the results accomplished, whereas the economic efficiency takes into account the cost as compared to other methods. The initial cost might be greater than other methods, but the lasting quality of its effect might prove the economy of the method. In other words, if it is necessary to clear certain streams three times during the season by hand, and burning once would accomplish the same results, then burning would be justified if the cost was something less than three times the cost of clearing by hand.

Before going into the details of the work I shall give a description of the apparatus used. The kerosene burner consists of a steel tank of sufficient size to contain 15 gallons of oil and a proportionate air space above. The tank is equipped with a double-acting, long-stroke pump which has automatic valves, a pressure gauge, and two burners each connected by a long rubber hose to metal pipes reaching to the bottom of the tank. The burner consists of a straight line of pipe and a coil at the end. The oil passes down the straight pipe, through the coil, and back to the base of the coil where it is atomized through a nozzle. In starting the operations the supply valves are closed, the burner coils heated until red and the air pressure brought to 40 pounds. Then upon opening the supply valves the oil is forced through the hot coils where it is vaporized and when sprayed from the nozzle readily ignites from the heat of the coils. It produces a bluish flame about 30 inches long and 4 inches in diameter. If the coil is not heated sufficiently before starting the blaze will be unsatisfactory; it will give forth a reddish flame which is of low heat value.

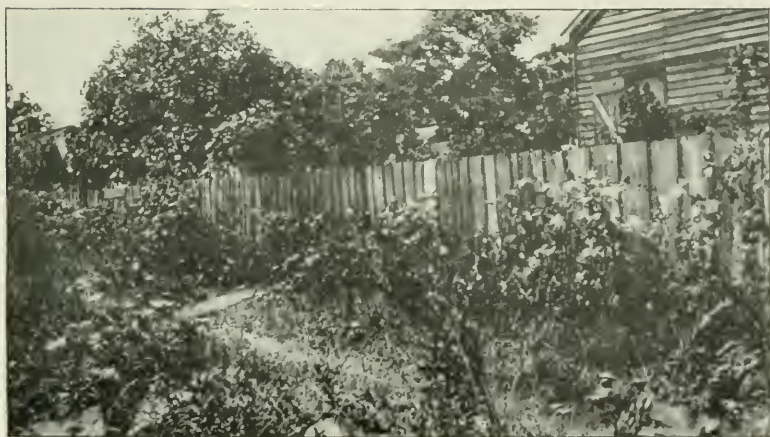
While operating the burner I used the full-time services of a foreman at \$5.83 a day, two laborers at \$2.75, handling the nozzles, using two nozzles continually, and one laborer at \$2.50 operating the pump. On the hand cutting I used a foreman at \$5 per day (figured as directing 10 men) and two laborers at \$2.50 per day. I made the comparison of these costs considering the laborers only, but I am



Before.

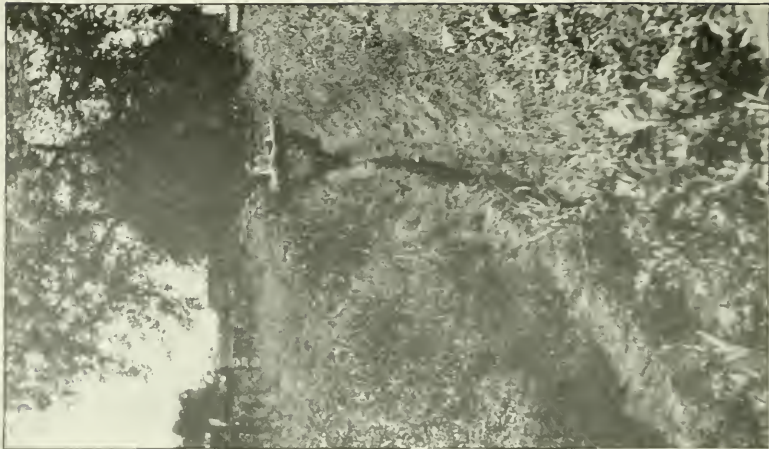


Burning.



After.

FIG. 3.—INITIAL WORK.



After.



Burning.

FIG. 4.—MAINTENANCE WORK.



Before.

of the opinion that the burners would not be operated very satisfactorily without some supervision by a person of more intelligence than the average laborer. I think that in operating two burners it is necessary to have three men, one at each nozzle and one at the pump keeping the pressure up to 40 pounds. As soon as the pressure is reduced to 30 pounds the coils seem to cool, and we soon have a low red flame, necessitating the reheating of the coil.

On the initial work, consisting of low grass and cocklebur bushes, about 4 feet high, on a length of 50 feet and a clearance of 5 feet, the burning costs 7 and 5 cents a foot, respectively, with and without the foreman. In addition to this it was necessary to do some hand clearing which cost 1 cent a foot. This brought the total cost including the foreman to 8.2 cents per foot and excluding the foreman to 5.8 cents per foot.

On another section of the same ditch having a like growth of vegetation, the work by hand, including the foreman, cost 0.48 cent, or approximately a half cent, per foot; without the foreman, 0.4 cent per foot.

The maintenance work consisted of a ditch which had been initially cleared a month and a half or two months before and was just at the stage where it was necessary to clear to get effective oiling. The vegetation had grown from each bank and had met so that it was not possible to see the channel we had previously cut. This work was conducted on a length of 177 feet. The operation of the burner, with the above-mentioned pay for laborers, including the foreman, cost 2 cents per foot; without the foreman the cost was 1.4 cents per foot. The handwork on this maintenance operation, on a like section of the same ditch, including the foreman, cost 0.4 cent per foot; without the foreman the cost was 0.35 cent per foot.

It will be observed that the use of the burner on fairly heavy initial work cost approximately sixteen times as much as the handwork; on maintenance work approximately five times as much as the handwork. The ratio is about the same with or without the foreman—close enough to put it in round figures. In two and one-half months the same growth covered the channel in the case of the maintenance example.

Another experiment was conducted in using this burner to destroy aquatic growth. Adjacent to Baton Rouge is University Lake, which contains a very heavy growth of *Myriophyllum heterophyllum*. Previous to this experiment we had cut 3-foot channel ways in this growth to admit *Gambusia* to the edges, and the control effected was very satisfactory. The work was done on the same basis as the hand cutting mentioned above and cost 3.6 cents per foot.

The burner was used to burn 3-foot channel ways for a length of 30 feet. Only one nozzle was used and the personnel consisted

of a foreman at \$5.83, one laborer at \$2.75, and one laborer at \$2.50 per day. The cost was 3 cents per foot, only a difference of 0.6 cent. This was not found satisfactory, because this growth, although we burned the top off, was so thick just under the surface of the water that it did not allow the minnows to reach the shore edge, whereas hand cutting gave very satisfactory results in this regard.

On another section of the lake bank where there was a very rank growth we made an observation as to the effect of using the burner along the bank, and I think in many places it might be very effective. At this place there was a very heavy growth of vegetation extending out about 20 feet from the bank. Vines and brush of all kinds present would have involved very heavy hand cutting to provide access to the lake's edge, whereas in a boat we could go in and about the edge and throw a flame that cleared out the underneath part of the vegetation. We could throw the flame a considerable distance and thus provide clearance for inspection along the shore where progress would have been impossible previous to that.

Accompanying this paper I submit several photographs which clearly show the nature of the work.

DISCUSSION.

MR. LE PRINCE. I would like to hear from Mr. Lenert if he has done any of this burner work.

MR. LENERT. I did a very small amount of this work due to the burner coming in late in the season.

We had one ditch, the head of the principal drainage system through the town, grown up with weeds to a height of 5 or 6 feet. The growth was very heavy and the cost for hand cleaning with hoes and shovels would have been very heavy. Work on this ditch was started with the burner and very good results were obtained on the growth near the ground, but being a very windy day, after the work had progressed about 40 feet it required the efforts of four men to put it out, and this work was discontinued. The ditch bordered a lumber yard and there was considerable danger of the fire spreading to proportions beyond our control.

We did try it on a ditch that had given us considerable trouble, being fed continuously by the leakage from a broken water main. The ditch contained water to a depth of about 6 inches and averaged about 5 feet wide. It was heavily overgrown with tall grass, Bermuda and some aquatic plants, to such an extent that the surface of the water could only occasionally be seen. This ditch was burned

off to the surface of the water, burning all of the light growth and scorching the heavier plants in such a manner that they would die, for a distance of 250 feet and a width of 6 feet. The cost may be itemized as follows:

1 foreman at \$4.81 per day ($1\frac{1}{2}$ hours)-----	\$0. 64
2 laborers, at \$3.50 per day ($1\frac{1}{2}$ hours)-----	. 94
6 gallons coal oil, at $19\frac{1}{2}$ cents per gallon-----	1. 17
Total-----	2. 75

This would indicate a cost of approximately 1.1 cent per linear foot. One-third more would be necessary to complete the burning of grass and weeds killed but not consumed, making a total of 1.5 cents per linear foot.

I believe the burner has a real value; while not taking the place of hand clearing, in some places, as in clearing the edges of ponds and lakes, it should prove far superior to handwork. We had one in particular surrounded with Bermuda grass. It would have been very valuable there in burning the grass to some distance above the water line, lowering the level of the lake some 6 or 8 inches before starting burning.

I would also like to experiment with the burner by first applying crude oil to the vegetation in a sufficient quantity to cause the tops to die and then applying the burner. There is no doubt that it has its good points and we have not yet discovered all of them. More thorough trials should be made.

Dr. FERRELL. The problem of getting rid of vegetation is extremely important. The work of Mr. Shaw is most interesting. However, it would probably be necessary to continue his experiments before we should be justified in drawing final conclusions as to the value of this method of control.

In the Southern States, the growth of vegetation and the production of mosquitoes is seasonal. As we go farther into the Tropics, both go on for 12 months of the year. There malaria is an even greater menace to the health and working efficiency of the people. The task of giving them relief lies ahead, and as opportunity offers, we should be constantly on the alert to find methods that will give them freedom from malaria. In the Tropics particularly, the cost of burning vegetation will probably be found prohibitive.

I should like to inquire if the experience of the sanitary engineers would lead them to feel that vegetation in many localities may be controlled by inclosing them with fences and utilizing them for pastures. In certain localities it has been feasible to collect the water in malarious areas within definite banks; control mosquito breeding with fish; and to pasture the banks with cattle and sheep, and thus control vegetation at a minimum expense.

Mr. FUCHS. Only certain kinds of vegetation are eaten by cattle. The question is, will cattle destroy the coarser and ranker growths that infest ditch banks? I have seen places where the vegetation was very closely cropped in the pasture, but on the banks of the ditch there were heavy growths of vines, shrubs, and briers that were not touched by the cattle. The beneficial effect of cattle on marginal vegetation is therefore questionable.

On the other hand, the cattle will trample ditch banks and leave hoof prints that will often become bad breeding places. Usually, then, the advantage to be gained from the removal of vegetation will be more than counterbalanced by the evil effects of hoof prints of the cattle.

Mr. LE PRINCE. I believe it is largely a question of topography. I have seen places in Louisiana where the grass is kept cropped close to the edge of the water. On the contrary, in my southern experience, time after time, we have found it better in handling certain areas, to keep a wire fence around a place to keep the cattle out of the place when we had a continuous rainy season. We have been able in some instances to get the farmers to pay for such work; in other instances we had to pay for it ourselves.

Mr. WOODFALL. I had a little experience along this line at Raleigh, N. C. We had a very bad low, swampy land under control. This piece of land had given us a great deal of trouble, due to local topographical conditions.

After the land was drained it was bought by a local man at an increase of 75 per cent above its original price and was used as a pasture for horses, cows, mules, and goats. We found that a combination of all these animals kept weed growth at a minimum, due to the fact that each type of animal would eat different types of growth.

From the maintenance standpoint we found the keeping of cattle was very expensive, even considering the factor of weed and grass control. As a final method the man was compelled to fence off all the ditches, keeping the cattle away from them.

Mr. LE PRINCE. Is there any further discussion?

We may find places where cattle can be used to advantage. There are many, of course, where fencing may have to be used.

The question of weed control or vegetation control is so important that much more investigation work must be done.

The next paper on the program will be "Culex control," by E. H. Magoon. This question should be seriously considered, but in our discussion let us omit unnecessary details; be brief, give us points of importance, and remember that we have to finish to-day.

CULEX CONTROL.

E. H. MAGOON,

Sanitary Engineer, International Health Board.

The control of *Culex* breeding is an important factor in an anti-malaria campaign. The cost of accomplishing this is often greater than the cost of controlling *Anopheles* breeding. As an illustration of this, I mention spending \$100 on inspections of wells, cisterns, and private containers at Trinity, Tex., during July, 1920. The same month \$13 was spent on oiling and \$35 on ditching and filling. The \$13 and the \$35 did much to control *Anopheles* breeding, but the \$100 gained the friendship of the people, and made them think the whole \$148 was well spent. Trinity is a town having about 330 houses, 145 metal cisterns, 130 underground cisterns, and 60 open dug wells. This town of 1,250 population is typical of other east Texas towns of its size. Its mosquito problems are chiefly ones connected with wells, cisterns, rain barrels, drains, septic tanks, and foul ditches.

Probably few people, other than experts, readily find *Anopheles* mosquitoes. This season I visited a school in South Groveton, a town where *Anopheles* breeding seemed particularly extensive. Twenty-five students brought mosquitoes they had caught. Not one of the specimens was *Anopheles*. I recall questioning different people about mosquitoes in a severely infected malarial district of Greek Macedonia in 1916. I was told that there were practically no mosquitoes. It was a district where *Culex* breeding was negligible, but a few *Anopheles* breeding places could be found. I mention this as it will serve to caution one against expecting that malaria reduction will necessarily result when one secures good control of annoying mosquitoes.

The warfare against *Culex* mosquitoes does more than make the work popular and insure continuance of appropriations for anti-malaria measures. It assists directly in the control of *Anopheles*. This past season *Anopheles* larvæ were found in common *Culex* breeding places. I make mention of finding:

Anopheles punctipennis breeding in underground cistern at house No. 278, Groveton, Tex., July 13, 1920.

Anopheles in six open cisterns at Groveton, Tex.

Anopheles quadrimaculatus in wooden watering trough near pond 17, Trinity, Tex., August 20, 1920.

Anopheles punctipennis in fire barrél at first railway bridge east of station at Corrigan, Tex., October 16, 1920.

Anopheles in nearly empty metal cistern near waterworks tower at Livingston, Tex., June 29, 1920.

Anopheles in cans, kettles, and tubs standing in or near the edges of streams and ponds.

The surface position and shyness of the *Anopheles* wrigglers hinders one from finding them in wells and cisterns. Most of the open wells and uncovered cisterns were stocked with fish early in the year and in consequence relatively few such places were found breeding mosquitoes of any kind.

The campaign against *Culex* breeding at Livingston, Tex., is outlined below.

1. Plat was prepared showing location of all dwellings, as well as streets and watercourses.

2. City council passed ordinance against mosquito breeding and solicited aid of ladies in the malaria census and educational activity.

3. Group of interested women was instructed concerning mosquito-breeding places and purpose of the campaign.

4. Some instructions and questions pertaining to screening of cisterns, downspouts, and cesspools and to stocking wells and underground cisterns with fish were printed on the reverse side of the malaria census cards.

5. These cards were used by the ladies who were securing data concerning mosquito-breeding places, and who were giving information about the antimosquito ordinance and methods of complying with it.

6. Census cards were looked over by the sanitary inspector, and fish were supplied to people who had replied in the affirmative to the question, "Does the owner wish fish put in the well or underground cistern?"

7. The first inspections indicated that 40 per cent of the premises were breeding mosquitoes. An inspection in August indicated that mosquitoes were breeding at only 10 per cent of the houses. The data secured by the inspections was published in the local newspaper.

8. A gummed poster bearing the words, "Warning; mosquitoes found breeding here in violation of health ordinance; abate nuisance," largely took the place of written notices. The poster was gummed on the reverse side so it could be readily applied to a galvanized iron cistern or a well bucket.

9. Opportunities were secured to inform interested people concerning mosquitoes and measures to prevent them. School children were shown exhibits of *Culex*, *Aedes*, and *Anopheles* larvæ and imagoes, and detailed instruction given concerning breeding places of the different kinds of mosquitoes.



FIG. 5.—FOUR OF THE 145 METAL CISTERNS AT HOUSES IN TRINITY, TEX.



FIG. 6.—CULEX AND ANOPHELES LARVAE WERE FOUND IN THE UNDERGROUND CISTERN TO THE LEFT OF THE HOUSE IN GROVETON, TEX.

The results of the campaign were most encouraging. People began to think of the mosquito problem as a local one. They were themselves able to locate and abate all mosquito nuisances.

Catfish, perch, and *Gambusia* have been used in the fight against mosquitoes. The catfish will keep a cistern or well free of wrigglers. Three pairs of *Gambusia* were just as effective as one or two catfish and there was not the danger of the fish dying and spoiling the water. Oiling with kerosene or gasoline will not kill the *Gambusia*. In June about 1,550 perch were seined and placed in fire barrels at the Rock Creek Lumber Co. Inspections showed that the two tiny perch put in each barrel grew rapidly and the barrels were free from mosquitoes.

Gambusia have been successfully used in preventing mosquito breeding in fire barrels, stock troughs, and rain barrels. Experiments showed that they would live neither in galvanized-iron cisterns nor in water drawn from them.

Mosquito larvæ do not appear to be harmed by blocks of red cedar floating in the water. Small films of oil seem to have little or no effect in killing larvæ in septic tanks.

DISCUSSION.

MR. LE PRINCE. I would like an expression from Mr. Hildebrand regarding other fish than catfish.

MR. HILDEBRAND. Mr. Chairman, experiments show that when fish are confined in containers almost any species may be used. Fish will eat what is available under these conditions even though it is not its natural food. I have used a strictly herbivorous fish and placed it in a pool where no plants were available but which produced *Culex* prolifically, and got absolute control. Place that same fish in an aquarium, or pool, with plant food and it will not notice a wiggler. I think in containers any species that may be handy can be used, but catfish may have advantages over the *Gambusia* or any other fish, because it is so hardy.

MR. VAN HOVENBERG. I want to ask if *Gambusia* will breed and multiply in containers?

MR. HILDEBRAND. In Key West, Fla., in cooperation with the naval health officers we stocked half a dozen cisterns with *Gambusia*, and they multiplied rapidly, but they never became abundant enough to cause any damage to the water. You know that *Gambusia* is a cannibal. When other food is not available it will eat its own kind, and they do not appear to become abundant enough to do any harm to the water.

MR. LE PRINCE. Another point in this matter of *Culex* control is the cost. It must be generally known that *Culex* control is essential.

Unquestionably many of you have found it advisable to take up Culex control.

I would like a general expression of opinion, just a few words from each one of you, as to what you spent for Culex control—whether you did \$50 or \$100 worth of work on Culex control. Has your Culex control been, say 10 or 50 per cent of your entire cost?

Mr. SHAW. I believe that the success at Baton Rouge in winning public sentiment was largely due to Culex control. The Culex control in Baton Rouge cost two-thirds of the total cost of oiling.

Mr. FUCHS. In North Carolina the per capita cost this year averaged \$1.25. At least 25 per cent of this was for Culex control.

Mr. LENERT. In Monroe, La., I should say 10 per cent of the cost of oiling and maintenance cost, exclusive of ditching, was for Anopheles control. In Bastrop hardly more than 20 per cent was spent for Anopheles as against Culex control.

Mr. DAVIS. I think in the work at Savannah we can safely say that 60 per cent of our mosquito control was for Anopheles.

Mr. LE PRINCE. Is there anybody here who thinks that the Culex control can not be omitted from our scheme of work? We would like to hear something along that line. Please be brief on these matters. Let us have a little further expression of opinion as to whether or not the public will stand for a continuance of malaria control work if the Culex elimination is omitted.

Mr. PARKER. I do not believe that in the majority of cases that the towns will want to continue the work unless we do Culex-control work. We have to conduct a mosquito campaign.

Mr. LE PRINCE. Just a minute, please, before further discussion. I want to ask this: Those who agree with Mr. Parker will please rise. Will somebody please count. Twenty-three.

Now, will those who believe the contrary please rise. Two.

Mr. HOSKINS. I believe that in rural malaria control, less attention need be paid to elimination of Culex than must be given in a thickly settled community. In a well-developed area, where Culex have been a pest, it has been my experience that this type must be eradicated if a campaign is to have continued local moral and financial support. On the other hand, officials of rural, malaria-infested territory will more willingly support a strictly antimalaria campaign, probably because of a higher rate of incidence of the disease.

Mr. LENERT. The work started by Mr. Hardenburg was continued by Mr. Park, one of Mr. Magoñ's trained men. At Navasota, Gambusia gave 100 per cent Culex control in a small creek. At Bryan they were used with signal success in dug wells and underground cisterns. At Calvert they controlled a long culvert that had previously given much trouble.

Gambusia are naturally present in large numbers in branches on the edge of Cameron, and it was found that one man using fish could handle the mosquito situation in town where it had required the use of two when oil alone had been used. In placing fish in street ditches and culverts they were allowed to dry up with the water, being replaced after the next rain.

This same procedure was followed in Monroe, La., by myself, using fish, which were very abundant in all the streams and ponds, in street culverts, ditches, etc., and it was found to be far superior to oiling in efficiency, speed, and cost where water continued standing for three weeks or more. They did not thrive in the outlet of a sewer overflow, however. Twelve hundred feet down the ditch, the same being fed from no other source, Gambusia were very plentiful.

I would like to make an observation noted in an inspection at Bastrop, La. After a rain a stock pond overflowed and the creek below contained some small holes, in one of which I found about a half gallon of water. In this water there were five catfish from 4 to 7 inches in length and two perch from $2\frac{1}{2}$ to 3 inches in length; no Gambusia. Along with them, floating on the surface, were five *Anopheles* larvæ nearly ready to pupate. It is possible that catfish may be better used in *Culex* control than in *Anopheles* control, due to the position of the larvæ on the water. It has been suggested to me that the use of catfish should be superior to Gambusia in underground cisterns, due to its habit of feeding in the dark, while Gambusia requires more light for feeding. Catfish used should not be larger than 2 inches in length, though it is claimed by a resident of Trinity, Tex., according to Mr. Park, that a single catfish in a dug well without a cover has kept it free of mosquito larvæ for eight years, where previously it had been a veritable hatching ground for mosquitoes. This catfish is still operating.

Mr. DEMOTT. From what I understand we are trying to conduct malaria control, are we not?

Mr. LE PRINCE. We are.

Mr. DEMOTT. If you have not funds enough to finance *Culex* control I think for the betterment of humanity you should conduct malaria control and let the *Culex* bite as much as they want.

Mr. LE PRINCE. We haven't yet got to the point that you have. We hope to get there when we can have county funds to handle the work on a big scale. The point is, we find so far we are not able to get communities to continue to finance this malaria control so long as they are bothered with the mosquito pest. When we have county funds we shall then be ready to operate a strictly *Anopheles* control campaign. It appears to-day there is a rapidly growing sentiment

for elimination of the mosquito pest, and the public is ready to-day to pay for mosquito control. There is a very small portion of the public ready to pay for *Anopheles* control. That is the situation. I hope the day is coming when we shall have you at another meeting, very soon, and be able to report otherwise.

Mr. MAGOON. This year we have used catfish control in about 400 cisterns and wells and *Gambusia* control in about one-fourth as many containers. I do not recommend catfish. The use of one or two catfish has no advantages and some disadvantages over the use of two or three pairs of *Gambusia*.

I believe it necessary to control mosquito breeding in open dug wells and cisterns in order to stop *Anopheles* breeding. I think mosquitoes would be found breeding in more open dug wells and cisterns if careful search were made for *Anopheles* larvæ.

Mr. LE PRINCE. The next paper is "Relations with outside engineering departments," by Mr. William Ropes.

RELATIONS WITH OUTSIDE ENGINEERING DEPARTMENTS.

WILLIAM ROPES,

Sanitary Engineer, International Health Board.

It has become almost an axiom with us that by far the greater number of mosquito-breeding places have been man made, but the courteous propounder of this truth delicately has refrained from telling us that many, very many of these are engineer made, and the worst of it is the engineer is making them still. As a class he needs education in the elements of malaria control as much as anyone else—more, for his opportunities for harm are much greater. It is our opportunity to educate engineers engaged in other lines of work and to secure their cooperation in malaria control. The particular branches of civil engineering which I have in mind are highway, railroad, drainage, and municipal engineering, their importance being generally in the order named.

It requires slight observation to see that the average engineer's ideas of drainage are entirely different from our own. A small amount of water, whether stagnant or running, is no menace to a road or railroad; in a big drainage ditch it is not considered at all. If a highway engineer finds it difficult to drain his ditches, he lets the water stay there or at best drains it away from the structure into a near-by borrow pit. Most highway projects have made little or no allowance for drainage, and the engineer in charge is simply obliged to do the best he can without exceeding his appropriation. Often he does not even seem to care; in fact, highway drainage is so generally neglected as to be a matter of comment in engineering publications. As I have mentioned, the highway engineer's ideas are quite different from ours, although they may be more costly, and I have not found that anyone has taken the trouble to instruct him in the elements of ditching as a malaria-control measure. There is an immense road building program under way throughout the country to-day and the responsibility of the public health engineer is as great to-day as it would have been during the great era of railroad building a generation and a half ago. It is a fact that in Arkansas alone it will cost many thousand dollars to undo the damage done along the new highways by the ignorance or carelessness of engineers, or those who pose as engineers. This is going on

to-day in other States as well, and I for one have taken pains to make the acquaintance of highway engineers in order to call their attention to the trouble that lack of proper drainage is causing, and have given them all the copies I could find of Mr. Le Prince's pamphlet on Drainage as an Antimalarial Measure to set them on the right track. It is a pleasure to state that the Arkansas highway commissioner is now providing for proper malaria drainage in all new highway contracts.

As far as the railroad engineer goes there has been so little recent construction it may be said that the damage is already done; the railroads are built with their undrained borrow pits, the inadequate, badly graded ditches, insufficient waterways, and high culverts. With a realization of the present condition of the railroads, of their insufficient funds for maintenance, replacements, and drainage, it is our duty to give the railroad engineer or roadmaster all the assistance we can in order that his limited appropriations may be expended from our point of view to the best advantage. I believe that a railroad engineer has often a wrong idea as to the scale on which ditching should be done, and I know that even last summer there was much ditching that was not only defective in design, but the ditches were much larger than necessary. This occurred in towns where work was asked of the railroads, and as a result of this magnificent scale the extra crews were unable to complete the work in the time allowed. It is particularly desirable to propose such plans for cooperation before the malaria season opens. When we commence our work, railroad plans have already been made, funds apportioned, and all that can be obtained is the small amount that can be diverted from actual maintenance of way; whereas if the chief engineer were informed of our plans about the first of the year he would then be able to take them into consideration when submitting his estimates for necessary work for the coming year. I believe in this way we could get more substantial cooperation from the railroads, cooperation which is often very necessary.

The drainage engineer seldom does much harm. Cooperation with him lies more in making our plans fit his, though when he does do a real mosquito-breeding job, he does it thoroughly and on a large scale. Some levees I have seen—recently built, too—were fine examples of what ought not to be. In general the trouble with drainage works is lack of maintenance; ditches are blocked with drift and growing trees, so that in summer they are a series of mosquito-breeding pools. The engineer is hardly responsible, for no effort of his has yet been able to impress the necessity of maintenance on the inert official mind.

One class only remains, the municipal engineer, the man who will help keep up in the cities the work we have begun. We should inform him as to the kind of breeding places that are produced by bad

design, carelessness, and neglect, and—if his funds are limited—which are the most dangerous and which he should attack first in municipal malaria work. The street-drainage question comes first in a small town; the waterworks in a large one.

In many towns in Arkansas intelligent street work will do away with from 50 per cent up to 90 per cent of even the *Anopheles* breeding places, not mentioning the numerous other mosquitoes. The water-supply system is a menace not because of the amount of water that leaks out, but because the leaks invariably breed *Anopheles*. I have found breeding in leaks from every part of a water system from the tank to the hydrant. In one instance a ditch a full half mile long was kept full of water and breeding *Anopheles* right through a town for two months by a leaky house connection. The town authorities were unaware of this leak until their attention was called to it. Leaky yard hydrants are a constant source of trouble, yet there are some designs that are nearly foolproof. We should indorse these. A fruitful source of annoyance is the familiar septic tank, yet it is just as easy to build a mosquito-proof structure over it as any, and oiling, if anything, adds to the efficiency of the septic tank. I have never found *Anopheles* breeding in a septic or Imhoff tank, but *Culex* breeds abundantly and I think it possible that *Anopheles* may breed in the effluent; in fact, I know they do in a septic tank effluent that is only diluted about 100 per cent with clear water. The street catch basin is a prolific breeder of several kinds of mosquitoes yet not many engineers know that recent practice discards them entirely.

The instances mentioned may be greatly multiplied and may be extended into other branches of engineering. Some of us are brought in contact with one class, some with another, and I am sure that if we are on the watch we will find opportunities in meeting these engineers to help and educate them and thus get better results, with the means at their disposal, in forwarding our own work.

DISCUSSION.

MR. LE PRINCE. The matter of screening that you brought to my attention—I want everybody to hear that.

MR. RORES. I happened to run across a novelty in screening this summer—at least it is new to me. There is a large girls' school at Searcy, Ark., having about 400 pupils, and screens were put on the windows and doors of the older dormitory about nine years ago. I do not know who conceived the idea, but these screens were of 16-mesh aluminum wire. These screens have been in place winter and summer for nine years, and so far as anyone can see they are just as good as the day they were put in. I don't know how aluminum would stand up in salt-water regions, but it seems to me it is worth

trying anywhere; it must be just as cheap as bronze, which we have used so extensively.

Mr. KOMP. I think I can beat Mr. Ropes's record by about two years. In Gulfport, Miss., on the Gulf of Mexico, one contractor whom I know very well tells me that he put screens on his house 11 years ago and hasn't touched them since, not even to paint them, and they are still in excellent condition. They are the Burrows Rustless screen, which I don't think is on the market any more.

Mr. LE PRINCE. We shall now consider the meeting adjourned until half past 1.

AFTERNOON SESSION, NOVEMBER 17, 1920.

Mr. LE PRINCE. We will have the next paper, "Financing an anti-malaria campaign," by Mr. N. H. Old.

FINANCING AN ANTIMALARIA CAMPAIGN.

H. N. OLD,

Assistant Sanitary Engineer, United States Public Health Service.

It should be understood that this paper, of necessity, refers only to urban, not to rural, work.

The first consideration in the subject of financing of a malaria campaign appears to me to be the budget.

Unfortunately the cost estimate or budget can not be framed in accordance with the size or resources of the community but must fit the local conditions of breeding. While the smallest possible budget may carry more appeal than a larger one, I have preferred to prepare estimates that I was sure would cover all costs, including emergencies of the campaign, at the same time stressing the point that absolutely no further appropriation would be requested later in the season on account of shortage of funds.

On this point I recall a remark made by a mayor of a small Georgia town last fall when the estimate was presented to the council. He was far above the average small-town mayor in business ability, and quickly asked my opinion as to how much in excess of that amount would be needed, for he said nearly all Government experts, to use his term, would estimate a certain amount for a job and find later that more was needed. There may be some truth in his version. At any rate I would rather lose a town than have to worry over finances in midsummer.

In this connection I will state that in the three Georgia towns worked this year there is an average of about 15 per cent of the budget remaining unexpended, and I find that this fact is having some weight, as a talking point, in continuing the work next year by making the financing problem lighter.

The next question is, From what source can this fund be raised? Usually there are only two possible methods of financing—by the municipal treasury or by public subscription, supplemented in some cases by aid from industrial concerns in or near the town. Often the condition of the municipal treasury is such that this source is out of the question, regardless of the attitude of the authorities; and I am frank to admit that in such cases I used to be discouraged, taking little stock in trying to finance a campaign by private subscription. But I am now a thorough convert to this method, for it possesses

three very distinct advantages: First, educational; second, the entire elimination of politics; and third, the arousing of community interest and individual cooperation. When a person's cash pocket is invaded, he will usually read the campaign reports and publications with interest and will aid in getting the greatest return from his investment. Understand, I do not advocate that municipal malaria control be placed on a permanent public subscription basis, but for demonstration purposes for the first year, especially where the municipal funds are low, I favor it. However, after the first year it should be financed from the municipal treasury, as is the fire and police protection.

Protection from malaria must be sold to a community almost in the same manner that a commercial salesman sells his wares. The need must be shown, the practicability of control measures stated convincingly, and a strong appeal made to the appropriating bodies.

While it is seldom possible to ascertain during a hurried survey the figure which would represent the total financial loss in a town, the need must be shown in some manner on a dollar-and-cents basis—as an investment, in other words. Perhaps statistics previously obtained for a town with nearly identical conditions could be used in this connection.

As to the demonstration of the practicability of control measures, it should not be difficult to cite many instances of good results obtained in communities in which campaigns were conducted this year. The nearer such communities are to the town in question the more interest will naturally be shown.

With reference to the appeal, it might be well to relate here a rather amusing, but nevertheless typical, incident. Last fall Mr. Tiedeman, a former service engineer, and I visited a small town of about 400 inhabitants in south Georgia for the purpose of making a preliminary survey. After finally locating the mayor at his sawmill, we proceeded to explain the exact nature of our mission; but when asked as to health conditions in that section, particularly malaria, he evidently judged we were contemplating the establishment of a business there, as he very promptly replied that the town was one of the healthiest in the State, hardly knew what "chills and fever" was. Knowing this to be untrue we went into more detail as to the purpose of our visit, explaining that we were there to help the town eradicate malaria, even to render financial assistance if necessary. From that moment his whole attitude changed and inside of 20 minutes he declared the town was a deathtrap, and pointing over to the cemetery his memory took him back, to use his own words, "to many a time when one funeral coming up the road would meet another coming down the road at the cemetery gate."

Incidentally this official was a strong advocate of vertical drainage, as he told us that what that section needed was holes put down through the ground to drain off the water by connecting with those "submoravian channels."

However, his attitude was that of many who become suddenly alert when outside financial aid is in prospect. Therefore it is a great help to have even a small amount of State or other financial aid to use as a lever for getting work started.

Attention should be called to the class of individuals and organizations whose interest should be solicited in financing a campaign. At Thomasville, Ga., it was the commercial and civic organizations, the latter composed chiefly of women, that were influential in raising funds in that city. As the women will be taking considerably more interest in municipal affairs in the future than ever before, it is well to secure their interest and cooperation to the same extent that the interest of the bankers, manufacturers, and business men is solicited. It seems reasonable to expect that the nineteenth amendment will aid materially in financing campaigns of this kind in the future.

A close study of Mr. Fisher's article in the May 28 Public Health Report headed, "What can a community afford to pay to rid itself of malaria," will be very valuable in presenting the economic side of malaria eradication to a body of citizens.

In Georgia, this year, Albany, a town of 12,000 population, financed its own campaign entirely, appropriating \$6,000, only about \$4,500 of which will be spent, thanks to Gambusia.

Cairo, a town of about 1,900, appropriated \$900 supplemented by \$300 jointly from the State and the International Health Board. The estimate for an oiling campaign was \$1,200, of which there will remain about \$200 unexpended. This town could not possibly have afforded a campaign including proper drainage and requiring an expenditure of about \$5,500. Therefore, rather than allow their interest to be lost, I outlined an inexpensive oiling campaign explaining that it could not be expected to be as effective as more thorough control measures. But I hoped to show some reduction, and had an entering wedge for securing a little better appropriation each year until the necessary drainage was completed. I would strongly advise anyone contemplating a curtailed campaign of this kind to make provision for a full-time inspector, except under unusually favorable circumstances. At Cairo the chief of police was placed in charge locally as inspector, but devoted very little time to the work. However, while it is too early to give definite figures, I find from doctors' statements that there has been a very satisfactory reduction in the prevalence of malaria as well as of mosquitoes, on the strength of which I believe my estimate of \$1,800 can be secured for next season.

At Thomasville the city was deeply in debt and did not provide a cent toward the budget, which was raised chiefly by private subscription. The county commissioners appropriated \$1,500, while \$3,500 more was raised by the activity of the local health officer and the manager of the commercial association, who were inspired by Mr. Le Prince's talk at a citizens' meeting. It was possible to arouse very little interest in the meetings held, judging by attendance, but the prospective contributors were hammered with letters and phone calls until the goal was reached. Despite the fact that the fund was not collected until June 1, necessitating a late start, the public sentiment at Thomasville appears to indicate that very good results have been obtained. The fall malaria census now being taken, I believe, will confirm this.

In conclusion, after a field man goes to the limit of his ability to put a proposition across and is still skeptical of success, I would draw special attention to a remark made by Mr. Van Hovenberg at the last conference which sums up my experience entirely in financing malaria campaigns. The remark to which I refer is, "If you are making no headway, I would advise telegraphing for Mr. Le Prince."

DISCUSSION.

MR. LE PRINCE. The subject is now open for discussion, but I wish to state the subject is not only financing an antimalaria campaign but also includes the question of approach.

Mr. Carter will open this discussion.

MR. CARTER. Mr. Chairman, I found in raising funds for the work in the towns that the various clubs, especially those in which the women are interested, were a great help.

It has been my experience that on approaching a town for the purpose of raising funds for an antimalaria campaign it is a good idea to meet and talk to some of the prominent business men, get them interested in the work, and request their presence at the meeting at which your proposition will be put before the town council.

In one town which I worked last year, I found the council opposed to any measure requiring an appropriation. After talking informally with the members of the council, I interviewed several prominent citizens and had them attend the council meeting when I asked for the necessary funds. Two or three of these citizens arose and demanded that the appropriation be made. Under this pressure the council appropriated the amount we had asked for. Had I not had the active support of these few citizens, I am sure the council would have refused to make the appropriation.

As I say, the various organizations, such as the chambers of commerce, civic association, Rotary Clubs, and women's club, are, I think,

the mediums through which we should work, and by so doing obtain very satisfactory results.

Mr. LE PRINCE. I want to ask you, Mr. Carter, supposing you had a new man coming on to this work and you were advising him regarding the general situation, just what would you tell him to do?

Mr. CARTER. Mr. Chairman, that is a rather difficult question. I don't think any definite method of procedure can be outlined which will suit each community. I would say, however, I consider it a very good plan to spend a few days in a town meeting and sizing up the people before putting the proposition up to them for final disposal.

In most towns of the size in which we put on campaigns, there are almost invariably one or two citizens who dominate the town. The question is to find them, cultivate them, and secure their confidence and assistance. Call on the bankers, lawyers, doctors, and merchants and explain to them just what you expect to accomplish with the campaign. After you have once won over to your side this class of citizenship, should the council not be favorably inclined, they are very apt to reverse their opinions and get on the same side with the leading citizenship.

Mr. LE PRINCE. I expected that when this subject came up you would all stand up at once. Now, I am going to be perfectly frank about things.

The first years that I was doing this sort of work I was a very successful failure, and I think we ought to talk a little of those failures as well as our successes, for the benefit of those who follow us. I am going to call upon Mr. Fuchs to talk along the line of the difficulties that a man runs into when he starts.

Mr. FUCHS. The matter of an appropriation for malaria control was brought up before the council of a certain town and representatives of the chamber of commerce and the women's club were present. Everybody seemed to be enthusiastic about it. One of the men on the city council who opposed the appropriation attempted by a clever maneuver, to table the proposition indefinitely by proposing the appointment of an investigating committee. That is the thing to be guarded against. Don't permit leaving the question to an investigating committee that may never report. I insisted upon having the matter thrashed out right there and then. I think the insistence on my part and on the part of the representatives of the chamber of commerce, that the matter be not tabled, but that it be decided without delay, saved the day, and they all voted in favor of it.

Mr. LE PRINCE. In recalling records of success I remember that several of us had the same difficulty I had; they learned how to succeed by failing, and I think you are all getting more expert than you used to be.

I admit frankly that I didn't know how to approach a community when I first had to do so. I am going to call on several to touch upon this subject; first, Mr. Johnson.

Mr. JOHNSON. I haven't had very much experience along that line, but I think that the most important thing is to get the doctors on your side.

Now, I fell down badly in getting three or four towns because I had opposition among the doctors. I find that when I have one or two doctors against me in a community I have not got a chance. The first thing I do in a town, before I make a survey, is to go in and see those doctors and get them together and talk the matter over with them, and since I adopted that policy I have been able to get along very well.

Mr. LE PRINCE. That is a very important point. I have made one big error. I once found so much encouragement at the chamber of commerce that I omitted to extend the proper amount of courtesy to the mayor of the town, and an unusual amount of care should have been taken, because the mayor of the town and the chamber of commerce were at odds, and I didn't know it until later.

Mr. SHAW. Referring to Mr. Johnson's remarks, I should think the engineer would be at a great disadvantage in most communities if he failed to present this matter to the city officials first. There are certain types of individuals in the persons of the mayor and health officer who wish to receive credit for initiating all municipal activities. In such cases should one present the matter to the doctors first, he will later meet with antagonism from the officials because they feel that their opinion has not been considered of first importance. I believe in bringing this matter to the attention of the mayor and then getting in touch with the business men and doctors, and if sufficient interest is shown, prepare the estimate and bring the matter up for final decision.

Mr. LE PRINCE. You heard yesterday Dr. Hayne's views of the matter of per capita cost. There are times in certain portions of certain States when it is advisable to take up a relatively expensive problem in order to get the desired public approval.

A very important project of this nature has recently been taken up and we would like to hear from the State sanitary engineer, Mr. Simons, in regard to it.

MALARIA-CONTROL DRAINAGE PROJECT, PERRY, FLA.

GEORGE W. SIMONS, JR.

Chief Sanitary Engineer, Florida State Board of Health.

At Perry, in Taylor County, Fla., the Florida State Board of Health in cooperation with the United States Public Health Service is executing its first intensive antimalaria campaign, one which measured by its magnitude, the variety and extent of control measures undertaken eclipses many such projects already completed in the South. The Perry project is undoubtedly one of the largest yet undertaken. The program now being followed at Perry includes practically every known means of combating the mosquito and bringing about its control, namely, (a) oiling, (b) fish control, (c) screening, (d) quinine prophylaxis, and finally (e) drainage. Of the latter work this article will deal mainly.

Perry is located in the center of a vast long-leaf pine timberland, about 115 miles west of Jacksonville and about 20 miles from the Gulf of Mexico. It is the county seat of Taylor County, a town of about 2,200 people, having as its principal industry the large mills of the Burton-Swartz Cypress Co. Within a few miles of Perry are located several other large mills of various corporations. The town is virtually the main center of trading and transportation for the surrounding lumber industry.

Topographically Taylor County is flat. At Perry and thence to the Gulf the average surface elevation does not much exceed 30 feet above sea level. The land is typical of piney woods and cypress swamp, the latter becoming more in evidence as one nears the Gulf. The superficial soil consists of a fine porous sand underlaid with a heavy blue clay and saturated sand. Near Perry, in spots, a porous lime rock is near the surface and along some streams lies exposed. Lime sink holes with disappearing streams and bubbling springs are to be observed in many places.

The standardized Vital Records of the Bureau of Vital Statistics of the State Board of Health indicate that during the year of 1918 Perry and Taylor County experienced high mortality rates from malaria, rates of 405 and 147 per 100,000, respectively. A comparative study of malaria incidence at other points in the State readily convinced the authorities that a project encouraged and carried to completion at Perry would result in an untold good among the inhabitants and to the lumber industries, also serve as a typical demonstration to the remainder of the State. Accordingly, during January,

1920, a preliminary investigation was instituted to ascertain the actual prevalence of malaria among the people, its effect upon the industries of the community, the attitude of the community toward malaria control and their readiness to assist in an undertaking.

The preliminary survey revealed a number of very interesting facts: (1) the whole community was intensely interested in any project which would relieve the malaria incidence; (2) the morale of the community was low as a result of malaria prevalence in previous years; (3) the local industries were vitally interested in any measures to reduce the malaria incidence and improve general health conditions among employees; and (4) enough patent medicines and febrifuges were annually purchased by people of the community the wholesale cost of which would almost defray the cost of a drainage project.

The residents of the community were alert to the needs and presented themselves as eager and ready to attack any task that could be outlined to them. Malaria had been assumed by many as a matter of course, and many there were who reckoned time by "the last chill." A house-to-house survey during January, 1920, indicated that during 1919 about 65 per cent of the people had malaria or "chills and fever," also that during the same period the wholesale cost of febrifuges sold by drug stores and other places totaled or approximated \$11,000. Following are tabulated the results of interviews at 218 Perry homes, relating to 1919 malaria conditions:

Number of families or houses interviewed	218
Number of people in houses	975
Number of malaria cases in last 12 months	632
Per cent of people having malaria	64.8
Number sick with malaria at time of interview	88
Per cent sick with malaria at time of interview	9
Deaths from malaria	3
Number of houses not screened	79
Number of houses not effectively screened	65
Number of houses effectively screened	74

Following the preliminary survey the facts were laid before the local town officials and a representative of the principal lumber industry, who readily saw the wisdom of a plan whereby the malaria incidence of the community might be reduced, the general health conditions improved, and labor conditions bettered. The town of Perry, with a civic consciousness believing in its future, immediately voted the sum of \$15,000 toward the initiation of a drainage project, and the Burton-Swartz Cypress Co. added \$10,000 to assist. At the time of the preliminary survey it was estimated by engineers that necessary drainage measures would consume approximately \$30,000.

The town of Perry lies between the forks of two meandering streams—Spring Creek on the south and Pimple Creek on the north.

These streams unite at a point near the east city limits and the Burton-Swartz mill property line to form the main channel of Spring Creek, which flows into Rock Creek and thence into the Gulf of Mexico. The Spring Creek channel flowing through the town limits is a small meandering stream having a wide, flat, and shallow valley or stream bed on either side which during times of high water is overflowed. Pimple Creek is a smaller, less meandering stream, and at one point in its course enters a lime sink hole into the ground.

At a point on Spring Creek there occurs a natural sink or "boil" from which a great quantity of water issues daily giving rise to a steady consistent flow through the channel line. Another sink formation is to be found at a point midway between the "boil" and the stream junction. Because of the several sink-hole "boils" and the disappearing stream formations in this locality it was very difficult to ascertain a well-defined drainage area for run-off computations in the drainage works design. A number of miles to the north of Perry what is locally known as San Pedro's "bay" is encountered. Once or twice per year this extensive semiswamp area, closely resembling cypress ponds, discharges water into the two stream forks. The quantity is sufficient to flood all the adjacent lands. About June 10th of this summer such a flood was experienced in Perry.

The preliminary engineering survey at Perry indicated early the feasibility of utilizing the two existing stream forks and the main channel as a basis for a more comprehensive drainage system. It was considered that a deepening, straightening, and widening of the existing channels would assist greatly in lowering the present water table, quicken the velocity of flow, eliminate the many bends, and hasten the surface water removal. The channels would also furnish an outlet for a future system of pipe drainage from isolated sinks and low depressions. In accordance, later surveys and studies were made along these lines, the project designed and contract let.

The final plans as being executed at Perry consist mainly of stream rectification work. The existing stream valleys are being used as a basis but only in long straight stretches are old channels being used and then only after a deepening and widening. All ditches have side slopes of 1 to 1 and the average cut throughout the ditches is about 6 feet. Following are given some of the original design elements:

Length of ditch.	Bottom width.	Grade per mile (about).	Velocity with 5 feet depth (per second).
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
4,300.....	8	2	2.2
3,400.....	7	2	2.2
9,000.....	4	3	2.3
5,000.....	3	4	2.6

As the work progresses some of the above elements may be altered to better fit the funds at hand, but generally speaking, the above are correct.

The estimated excavation will amount to about 47,000 cubic yards, about 20,000 of which will be handwork, the remainder machine work.

As stated previously, it was difficult to ascertain a well-defined drainage area for the purpose of run-off computation work, because of the presence of so many limestone sink holes and "boils"; then again the exact nature and action of San Pedro "bay" was not well known. Inasmuch as the entire project was for surface water removal mainly and not for agricultural purposes, an arbitrary drainage area amounting to approximately 3,500 acres was assumed. A run-off of 1 inch per 24 hours was also assumed, and upon such basis the channels were designed.

The actual construction work was commenced by the contractor on June 24, and already much of the eight-foot bottom section is completed. In the course of construction considerable running, or heavily saturated sand, was encountered. This will be removed either by suction pumping or dynamite. Overlying the sand much heavy, sticky, blue clay was handled.

The remote location of the work, the scarcity of local labor supply, the extent or size of the job, and its emergency nature precluded the placement on the job of the best and most ideal equipment obtainable. Ideal equipment was largely occupied on larger works elsewhere or their owners would not consider bringing it into the district for such a small job. Consequently the machine now working is not the best suited nor the most economical, but at the same time is of a type which is progressing slowly and doing a neat work. Had more time been available for the selection of equipment a more suitable machine could undoubtedly have been secured, but experience in the large southern drainage districts indicates that oftentimes the most ideal equipment can not be readily put to work.

The entire contract will total about \$31,000, which for the community amounts to nearly \$16 per capita.

In addition to the open channels a number of small pipe lines will be laid from remote sinks or depressions to the channels; also from low-lying properties bordering the stream valleys. This latter work will for the most part be done under a local city ordinance empowering the authorities to request property owners to drain any areas specified.

During the summer months while the ditch construction was progressing slowly, oiling, screening, quinine prophylaxis and fish-control measures were enforced to control mosquito prevalence. As a result of these several activities malaria incidence, and also mosquito incidence, were greatly and perceptibly reduced.

Comments from many citizens and members of the medical profession at Perry tend to indicate that there has been a decided bettering of conditions this past summer. Of course improvement is probably due to many factors, but the above named play an important part. Several doctors claim malaria has been "a scarce article" in Perry this season; other citizens claim this is the first time they have been able to sit on their verandas in years. One professional man informed the writer that after a few years in Perry he was becoming discouraged and was about to sell out and leave, but the summer's activities, combined with prospects for good drainage, gave him courage to stay, and instead of disposing of his property was going to invest in more property and boost. One fraternal organization that previously rented quarters devoted one night to prospects and their future. After a long deliberation it was decided, in view of the drainage measures undertaken, to invest and build a three-story structure. Such incidents are common and encouraging in their tone.

Drainage measures were under the supervision of Asst. Sanitary Engineer J. G. Foster, U. S. Public Health Service. The prophylaxis, oiling, general conditions, and much of the residential screening were under the direct supervision of and executed by Dr. A. C. Hamblin, district health officer, of the State board of health, who was assigned to duty at Perry. Approximately \$1,000 worth of quinine was distributed by the State board of health during the summer months. Solar oil of the Gulf Refining Co. was used in oiling ponds, pools, ditches, and streams.

Early in the year the city council at Perry promulgated a screening ordinance requiring all residents to screen windows and doors. During the summer months inspectors of the bureau of engineering of the State board of health were active in enforcing the order in cooperation with the Perry marshal. The results have been very successful, and to-day at least 90 per cent of all homes are screened thoroughly. It is an encouraging sight to pass through a section of colored huts and see all openings screened and tightened up. In addition to house screening the State screening law was enforced at all groceries, markets, drug stores, fruit stands, or other places where foods and drinks are offered for sale.

Sanitary inspectors of the bureau of engineering were active in Perry all summer doing general sanitation and clean-up work. Rubbish and refuse of all description were frequently removed, and since August 15 sanitary privy construction has been under way. Up to November 1 no less than 150 new sanitary pit privies dot the town, another inspiring sight.

Under Dr. Hamblin's supervision much hookworm and trachoma work has been done, work worthy of great commendation.

The drainage measures now under way will be completed about April 1.

MR. LE PRINCE. I think the State Health Department of Florida has done correctly, and I don't doubt but what after this work is done their future problem will be to find enough trained men to take care of the applications for malaria control that come to the State health department. I think it is a splendid beginning to select a place that is so unusually malarious.

MR. SIMONS. I might say that since we started, the nature of the work has got around the State until we have now applications for four additional projects, and they are all of them larger than this one.

MR. LE PRINCE. The next paper will be "Subsoil drainage," by Mr. J. G. Foster.

SUBSOIL DRAINAGE.

J. G. FOSTER,

Assistant Sanitary Engineer, United States Public Health Service.

Very much of the work of ditching, channeling, and pipe or tile drainage with which we have to deal is along or near previously existing natural or man-made watercourses. In most of our work main drainage systems are generally as nature provided them, with small alteration by man. Usually they need cleaning and training throughout their entire length. Their constrictions, where bridges, culverts, and other passageways over them occur, are of great interest in malaria control operations.

Structures providing artificial waterways should be of such design that drift will not lodge in them, and of such cross section that large scouring action will be avoided at the effluent end of the structure. Sometimes slight constrictions are of value, as the increased velocity induced by them will remove small trash which might otherwise provide breeding places for Anopheles.

We should provide for adverse conditions, such as occur at low water and at flood flow. If there can be choice of two designs in planning bridges or culverts, the simpler device with one wide opening is to be preferred. Sometimes lack of headroom makes it necessary to lay pipe or make culverts in several small units, where one waterway of larger vertical dimension would suffice. The single outlet of large diameter is preferable, even though it might be slightly inadequate at flood flows. Where more than one culvert must be installed, due to the lack of headroom, if possible one culvert should be set lower than the others, which should have their inverts at least above the level of ordinary flow. This construction is preferable, even though more lines of pipes be required to care for flood flow. The deepest culvert may have a minimum allowable gradient, since it is presumed always to carry some flow. The other lines of culverts may well be on steeper grades, but no part of their bores should be below the ordinary water surface at their lower ends.

These flood flow lines should be laid to a grade in a vertical curve tangent to the horizontal at the influent end. This will allow for some subsidence of culverts under embankments and under heavy traffic without forming pockets in which water might collect.

Probably this device of staging the levels of multiple culvert installations should be employed only where as much as 10 inches vertical difference in stage may be had; otherwise an oil film could not enter the upper conduits.

Sometimes advantage may be taken of the free oiling provided by utilizing waste obtained from garages and machine shops. If such wastes are conducted directly into sanitary sewers they are lost for our purposes, but if they go directly into storm sewers the oil is sometimes very effective in preventing breeding along the course of the outlet stream.

In urban communities, where considerable street paving has been done, there is usually a separate sewer system to carry off storm water. Catch basins for the storm sewers usually are placed from 100 to 300 feet apart, and are provided with a grating or curb box at the intake. Grit chambers or sand traps are placed at the bottom of the catch basins, with the bottom of the grit chamber from 8 to 15 inches below the invert of the pipe leading to the storm sewer. These grit chambers generally hold water long enough to propagate mosquitoes, and due to the admixture of organic street refuse with the retained water, usually breed them prolifically. However, only a small percentage of mosquitoes breeding in catch basins are *Anopheles*. It is not practicable to screen curb or grate inlets for storm sewers. Sags and inequalities in grade or ponding of water by accumulation of drift and sand within the sewer pipes themselves serve as breeding places. This type of breeding place is usually best controlled by oiling, although periodic flushing of the entire system, either by rains or by water under pressure from the city mains, will be of great aid. The breeding in catch basins is sufficient to maintain a small supply of mosquitoes throughout the season, which serve to keep seeded large areas, which otherwise might be entirely free.

An attempt should be made to have all future storm sewerage so constructed that a weepage way is provided from the bottoms of grit chambers to the sewer main. This might be a 1½-inch galvanized-iron pipe, equipped with an upturned entrance and a brass strainer, and a perforated sheet-metal shovel guard about 3 inches square, set in a recess in the bottom of the chamber. The slope in the galvanized pipe would need to be very slight in order to completely drain the grit chamber before breeding could occur. This method is dependent on the slope limits.

Catch basins in many instances are the chief source of mosquitoes in urban areas. They are dangerous because they provide water charged with organic matter, such as horse manure, in an environment with modified light and equable temperature. Their danger lies particularly in their nearness to an abundant blood supply, with consequent opportunity for prolific egg laying.

Lot owners should not be permitted to construct any sort of grit chamber on their premises. All detritus from earth washings can be caught in the curb sand trap or grit chamber. Attention should be

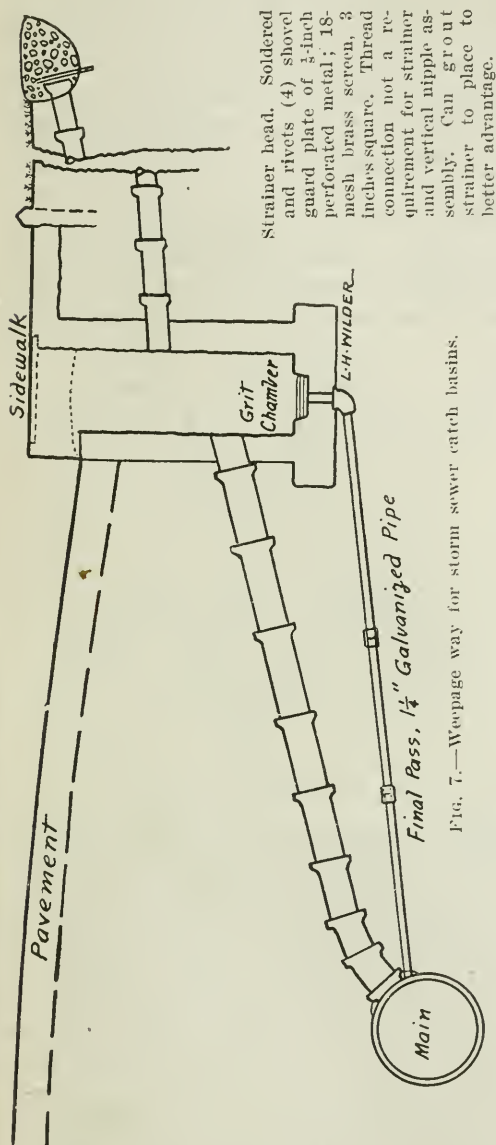


FIG. 7.—Weepage way for storm sewer catch basins.

be called forcibly to the dangers in storm sewer catch basins as sources of mosquito breeding, as otherwise the local authorities may neglect them in future years, to the great detriment of our work.

In the outlying suburban areas of a town there will usually be found an extensive open-ditch drainage system, provided by the property owners to a large extent, but often installed by the public authorities to provide an outlet for the town's drainage. These are usually neglected after their construction, and almost invariably are in need of considerable work to place them in serviceable condition. Such ditches are usually from 1 to 5 feet deep, and from 2 to 3½ feet wide at bottom. Their side slopes are frequently of the so-called "natural" appearance; i. e., to an observer standing in the ditch the upper half of the slope is somewhat convex, while the lower half is concave. The spoil banks on the sides

of the ditches are usually continuous, and no waterways are provided through them, with resultant impounding of water along the banks. In order to obtain grade, the ditches are dug deeper at the lower or outfall ends, and the resulting greater amount of spoil is not dis-

tributed evenly, but piled higher along the edge of the banks, causing caving and obstructions in the stream bed. Water grasses and algæ further make trouble by destroying the continuity of an oil film when oil is used to control breeding. Frequently the ditches forming the outlying drainage system of a town hold water all year round, and sometimes they breed so many mosquitoes that man's work in making them has provided a more favorable breeding ground than the original ponds and pools, which would have been extensive only during a part of the season. Such ditch work can be made temporarily safe by clearing and oiling.

When the permanency of the work is to be considered, it may often be feasible to employ a combination of open-ditch and tile drainage. Thus, large ditches may carry off the excess flows, while lines of tile laid in the bottoms of these ditches may care for the water that

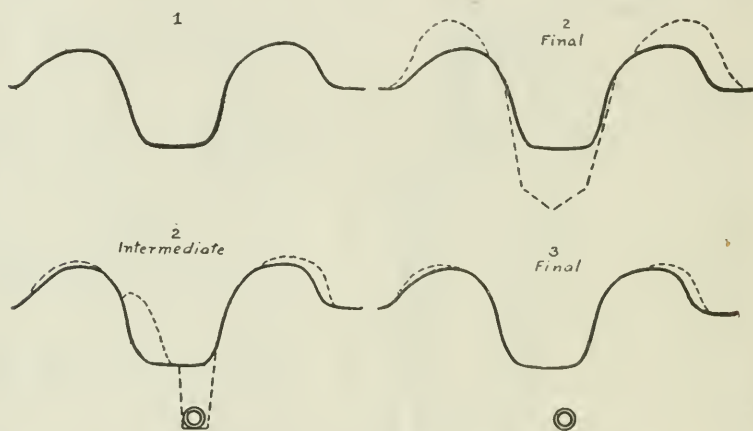


FIG. 8.—Showing elective methods for ditch improvement.

otherwise might lie in depressions along their courses. The cost of installing such tile should not be very great, as the amount of earth to be excavated will seldom be greater than the displacement of the tile. Conditions are favorable for this sort of work if the tile drains can be emptied into a deeper natural channel or ditch. Where no difference of level occurs, it will be necessary to go below the termination of the tile drain, and lower the bottom of the ditch to provide an outlet for the tile. At such outlets there should be a riprap flooring to prevent flood flow from soon equalizing the bottom slope and disturbing the pipe outlet. One-third of a cubic yard of brickbats will make a satisfactory barrier, usually. Brush and stakes can be employed with good results for the purpose, if better material is lacking.

Pipes of bell and spigot design are preferable for this sort of work, even for as small diameters as 4 inches. In buying pipes,

economy may be effected by taking what are termed "seconds," as for conformation, i. e., slightly "out of round," not quite straight, or with cracks through bell or spigot, provided they be "season" cracks, made before the tile is burned. No pipes with cracks formed after burning should be accepted. Hard burning of all pipes must be a positive requirement. Such pipes will afford a durable job, and will cost from 30 to 50 per cent less than standard sewer pipes, which are rightly required to be of nice form in all respects in order that joints made in sewer lines may be as tight as practicable. In our work we wish to admit as much water as possible to the pipe; but sewer designers wish to exclude all ground water. Pipe lines will usually be laid "dry," cement joints being rarely employed. In clay ground and in loams, pipes should be laid with ends up tightly, but with no joint materials whatever. In free-running sand, oakum, or waste cotton or rags are useful as a joint-making material; if near at hand a crude asbestos supply would be preferable if not too costly. On most jobs not 15 per cent of pipe work will need any sort of joint packing. After pipes are laid it is well to place vines, brush, and trash over the joints of the tile before back-filling.

As a general rule all trees within 30 feet of a tile line should be killed. Oaks and pines are not apt to make trouble, but roots of elms, hackberry, and other allied trees are sure to clog the entire bore of the pipe after a few years.

Where only small pipe is required in clay ground, 3 or 4 inch ordinary farm drain tile may be used. They should be laid at a depth of not less than 1 foot, as otherwise hogs or cattle may disturb them. Work done with such plain tile is much improved by wrapping the joints with cheap one-ply tar roofing paper in 3-inch wide strips. Where a pipe line is to be covered with not more than 8 inches of soil, it should certainly be of bell and spigot pipe. No direct openings should occur in drain pipe lines, and where large amounts of water must gain access to the tile, rough filters, such as will readily pass water but stop trash and vermin, should be constructed. Such a filter may be made by excavating a chamber beneath the grade of the pipe to a depth of twice the bore diameter. This chamber should be circular, with a diameter at least three times that of the pipe. This chamber should be filled to the grade of the pipe with 3-inch broken stone or brickbats. Then choose a pipe from which about one-third of the bell has been accidentally broken, and another pipe which has lost a part of its spigot, and scallop away what would be a semiellipse if it were flattened out, so that about one-quarter of the pipe circumference is taken away at the spigot. The length of the scallop back from the spigot should be about three-quarters of the interior diameter of the pipe. Assemble the two pipes in such a manner that the resulting opening

faces downward on the filter substructure already prepared. Use a few small iron rods placed nearly vertically, or some galvanized mesh fencing, to prevent filter material from getting into the pipe line, then continue the filter up to the ground surface, expanding it

as it rises to an effective diameter at the top of four to five times that of the pipe. A filter such as is described which serves as the outlet at the sump of a pond should be heaped up well above the surface of the ground to prevent interference by ploughs and vehicles. Filters on pipe lines in street-side ditches should be built at about 50-yard intervals, and should be graded to half-inch material at the top, to prevent boys from throwing it away.

The cobble-filled trench or "French" drain, as the texts of 20 years ago termed it, and the three green poles with vines and grass overcoat, the whole covered with soil, are devices of merit, and should not be overlooked even in this day of factory-made devices.

A very high authority states in his paper entitled "The Malaria Problem of the South" (Bureau Reprint No. 552): "I count drainage, especially tile drainage, the key to the rural malaria problem." A very trenchant

remark it is, and the writer is grateful to be able to quote it in closing this paper.

DISCUSSION.

MR. LE PRINCE. Gentlemen, to open this discussion, I wish to ask Mr. Foster if he will kindly supply us at a later date with a

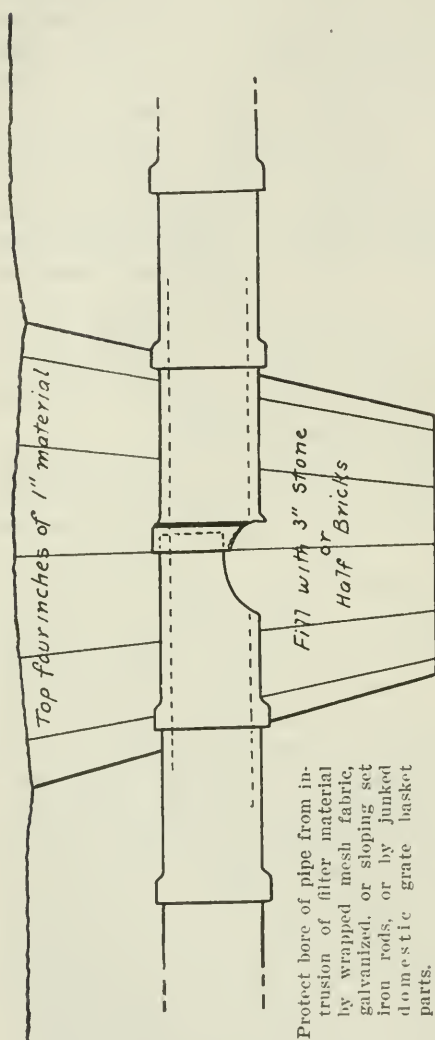


Fig. 9. Rough filter for use in drainage operations.

copy of this diagram so that it can also be put into the record, and I wish to call your attention to some of his work done at Fayetteville, N. C.

Mr. FUCHS. Mr. Chairman, the subject of street catch basins is one, I think, that has been a thorn in the side of every man who has had urban mosquito work to do. But while I should like to see Mr. Foster's plan work, I am afraid that the natural street sweepings or washings will in a very short time clog the strainer at the small outlet to the lower pipe that he proposes, so that it will not be effective.

I should like Mr. Foster to state whether he has taken that possibility into consideration.

Mr. LE PRINCE. Any further discussion?

Mr. CLARKE. At Coffeeville, Miss., I laid about 1,000 feet of 5-inch farm tile drain. It was put about 18 inches below the bottom of large street ditches, which had been constructed wider than necessary in order to get the required grade, and the street ditches were filled to form ordinary sized gutter ditches. This not only removed standing water, but improved the appearance of the street.

Mr. LE PRINCE. Any further discussion? I will ask Mr. Foster to close.

Mr. FOSTER. Mr. Fuchs asked a question as to the clogging of the strainer that I talked about. I know that that is a matter for the future to solve; we will have that trouble continuously. I confess that I don't know that that is the best method at all. I don't know how much space should be given to the making of the strainer head which should be put on the contrivance. It wasn't expected it would unwater the basin in an hour; if it would unwater it in three or four or five days we would be very well satisfied, and I advanced it simply for consideration. I would be glad to see some one carry it further.

I wish to state that a good bit of tile drainage is being employed on the Perry project to drain ponds in back of some rather high spoil banks, which in a great many places will have to be continuous. These lines will be only 100 to 200 feet long, and will be equipped with filters at the inlet end.

Mr. LE PRINCE. The next paper will be "Propaganda for selected towns," by Mr. L. G. Hastings.

PROPAGANDA FOR SELECTED TOWNS IN CONNECTION WITH THE DEVELOPMENT OF ANTIMALARIA CAMPAIGNS.

L. G. HASTINGS,

Sanitary Engineer, International Health Board.

The successful development of an antimalaria campaign depends upon the interest that can be aroused in the citizens in general. For this reason it is very essential that such propaganda be disseminated and such a slogan developed as will awaken the people to an active interest in the malaria situation. To do this, it is necessary to become acquainted with members of local organizations, such as city councils, chambers of commerce, Rotary Clubs, women's leagues, labor unions or councils, large business enterprises, and the prominent citizens of the town. Through these organizations the public may be educated regarding the contemplated sanitary movement. We can not expect the hearty cooperation of any people until we have acquainted them thoroughly with the public health movement we are about to launch.

Upon entering a community for the purpose of developing an antimalaria campaign the first step should be to get in touch with the mayor, and get his attitude on the subject. If it is favorable, use it to support the campaign: if unfavorable, he should be educated first. After you have become acquainted with the mayor and other city officials request that one of them take you to see each of the local physicians, and from them secure all data available relative to the prevalence of the disease. State the purpose of the survey and arouse their interest and sense of duty.

Next arrange for meetings of the local organizations such as the chamber of commerce. It is essential that a notice of these meetings appear in the local newspapers to insure a large attendance. It is probable that you will have an enormous crowd, especially if the people are continuously molested with the mosquito pest. Such occurrences are very common in most of the towns of Arkansas. During your interviews with such organizations discuss the exact nature of the contemplated campaign. Explain the results they may expect after the first season's control measures, and lay particular emphasis on the small expense of the control measures. It is not necessary to go beyond certain limits with this cost discussion, as it will be presented when the final report is made. If you have any

letters of indorsement or commendation from officials of other towns where you have carried on successful control measures, they will prove very valuable if read to your audience. Letters of this nature from mayors or health officers of such towns carry more weight than if written by others.

After you have addressed the local organizations, see the principals of the graded and high schools, explain to them the details of the malaria campaign and the necessity of educating the citizens in this direction. Have them talk malaria and mosquito control to their students, and request that they make this study a part of their curriculum in connection with the science courses. Such instruction to the children is valuable, for they will carry their new learning home and will do considerable toward the eradication of breeding on private premises. The instructors should be supplied with Carter's Malaria Primers and other literature which may prove helpful. The Arkansas State Board of Health is supplying certain leaflets on malaria to be pasted in school textbooks. This leaflet is quite elementary, but contains fundamental facts relative to the cause and prevention of malaria, and seems to be very well designed for pupils of the primary grades. If possible give an illustrated lecture on malaria and mosquitoes to the students, but guard against the use of too many scientific terms. The pupils will be attentive provided they know just what you are getting at.

It is often desirable to interest the influential ladies of the town in the malaria problem. Their aid is valuable when the time comes to launch the campaign. The ministers of the town are usually glad to mention public-health activities from their pulpits; they are also influential in their community. On several occasions I have been interviewed by certain district insurance agents who were able to talk malaria intelligently. They are interested in the malaria situation and often offer considerable assistance by having their local agents distribute malaria literature to the people free of cost. It is very desirable to secure the support of these men and it is possible that they may make a malaria census for us later.

Another method which is very effective is the presentation of malaria slides at intervals on the screens of movie theaters. It is suggested that some provision be made for securing a supply of slides for this purpose like those used for hookworm, tuberculosis, venereal diseases, etc. Have the local health officer or other qualified person present a brief outline of the malaria situation and the contemplated work just before the slides are shown. This idea was furnished me by one of the citizens of Prescott, Ark., while in that city for the purpose of making a preliminary survey. Brief articles on malaria appearing in the newspapers are effective. By this

method we are able to reach the people who were unable to attend the lectures. If possible have the city health department print malaria dodgers to be distributed throughout the town. These should be very plain in order that they may be understood by all classes of people. In Fordyce, Ark., a sign painter preparing advertisements was requested to preserve one section of his billboard for these words: "A successful antimalaria campaign is being conducted in Fordyce." It appears to me that such an advertisement will be a boost for the town and would be to a certain degree instrumental in causing the town people to see that the work did not fall through once control measures have been inaugurated.

DISCUSSION.

Mr. LE PRINCE. The subject is open for discussion. I think the question that was brought up regarding the importance of propaganda being used in the towns in advance is a matter deserving our consideration.

Mr. LENERT. Only a portion of the State of Texas is within the district in which malaria is endemic. This naturally gives rise to an argument between the western part of the State and the eastern portion on such questions as the location of State institutions. The Agricultural and Mechanical College is located at Bryan, one of the points at which Mr. Hardenburg carried on a demonstration during the past season. When the campaign was started in the spring the citizens of Bryan generally objected to calling it an antimalaria campaign, being afraid that it might give ground for an argument against Bryan as a pesthole for malaria. The campaign therefore lost one of its strongest talking points and it was necessary to consider it principally from the nuisance standpoint.

Mr. LE PRINCE.—The next subject on the program is "Tide-gate operations at Savannah," by Mr. Davis.

TIDE-GATE OPERATIONS AT SAVANNAH, GA.

W. A. DAVIS,

Special Expert, United States Public Health Service.

Savannah is located on the Savannah River at a point about 18 miles from its mouth, at which point there is a normal tidal rise of about 7 feet. The elevation of the city at a point about 100 yards from the river is about 45 feet above mean sea level. Running south there is a gradual slope until an elevation of about 8 feet above mean sea level is reached. On the east and west sides of the city are the low rice-field lands. These fields, long abandoned for rice culture, are from 3 to 4 feet below mean high tide and in their natural state are subject to overflow from the tidal variations in the river. In addition to the tidewater which covers this area, extensive drainage canals from the swamps of the county pass through these lands. The tremendous volume of water accumulated in the swamps during the rainy season, added to the natural overflow of the tidewater when these lands are undrained, creates conditions that makes tide-gate control imperative. A combination of methods was adopted for the control of these fields and canals.

As early as 1817 the citizens of Savannah realized that these low rice-field lands, in an inundated condition, were a menace to the health of the people living in Savannah and especially those living in the areas adjoining them. This is evidenced by the following extracts taken from an article, *The History of Dry Culture*, written and published in 1826 by the late Dr. W. C. Daniell:

In 1817, at a town meeting, it was resolved that about \$70,000 should be appropriated by the city to the purchase of the rights of cultivation, in wet culture, of such of the tide swamps as were adjacent to the city. These lands were accordingly subjected to dry culture, by contract, at the price of \$40 per acre; and the system went into operation the following year. Its success at first surpassed the expectations of its warmest friends.

Six years have now passed away under the operation of the dry-culture system. Imperfectly as that system has been enforced, it has given proofs the most conclusive of a favorable influence upon the health of Savannah.

The lowlands are divided by the city, thus making two separate drainage systems, one on the east side, the other on the west. There were numerous ponding areas, and the old ditches were filled with a rank growth of aquatic and semiaquatic vegetation which were ideal and prolific breeding places for *Anopheles quadrimaculatus* and *Anopheles crucians*.

In these two areas the construction of dikes along the river to keep the flood tide out was unnecessary, the fields having been filled to a level above high-water mark for some distance back by dredging out the channel in the river and the construction of terminals and slips along the river front.

Through the low lands on the west side runs Springfield Canal, which empties into the Ogeechee Canal at a point about three-fourths of a mile from the river. Springfield Canal is the main drainage outlet for the rice fields through which it passes, also for a large swamp area in the county adjoining the city; several of the county drainage canals emptying into it.

At the time malaria-control operations were started in Savannah, March 20, 1920, the low lands on the east and west sides of the city were in an inundated condition, the drainage and tide gates having been neglected for several years.

The first work toward reclaiming and draining the fields on the west side was to repair the existing tide gate in the Ogeechee Canal. This gate is located at a point near the river and when properly functioning keeps the flood tide in the river from backing up in the canal and overflowing the fields. It allowed the accumulated water on the fields to drain into Springfield Canal, which, when kept at low-water mark, acted as a drainage basin. The accumulated water in the canal basin drains into the river via the Ogeechee Canal through the automatic tide gate at low tide. As a safety factor and to better control the storm water that might accumulate in the main drainage canal, the banks of which are much higher than the ground level of the fields, small tide gates were installed, as was deemed necessary, in the main drainage ditches of the fields. These gates proved their value on several occasions this past season. During the heavy rains the drainage water from the swamps would accumulate in the canal basin at the period of high tide in the river, nearly filling the canal to overflowing. This water is held in the canal by the small gates, running off at low water in the river through the main tide gate.

After the water was drained off the fields and the ground dried out so that a laborer could walk on it without danger of becoming bogged, the existing ditches, which were adequate to drain the land, were cleaned. First the dense growth of aquatic vegetation with which they were filled was removed, rakes being used for this work. Later mud scoops were used to remove the soft mud in the bottom and thus lower the water level in the ditch to low-water mark in the canal. In this way the water level was lowered from 2 to 3 feet, and in many cases the ditch would run dry unless we had continuous heavy rains. No new ditches were dug except a few short laterals to low ponded places.

The operation of draining the fields on the east side differed only in that the main drainage ditches from the fields emptied directly into the river. It was thus necessary to install a tide gate in each main drainage ditch.

Various types of tide gates and sluice boxes are in use in different parts of the country. The type used in this project, with two exceptions, is known as the old rice-field type. This type of tide gate when properly constructed and installed has proved very satisfactory and dependable. It is the type used by the old rice-field planters, having stood the test of years, and best suited to their needs.

The construction of this sluice box differs very little from other types. The shutter, instead of being fastened to the top of the box with hinges, is hung on posts fastened to the side about 20 inches from the outflow end, at the proper angle to conform with the outflow end of the trunk. The gate is hung between these posts on an iron pipe or rod. It is so balanced with weights that it will operate at the slightest difference in the pressure of the water on either side. This type of gate is very easily repaired. It can be raised or lowered for repairs or replaced by a new gate without building a cofferdam around the mouth of the trunk at any stage of the tide.

In installing new sluice boxes, a point to observe in the determination of the elevation of the box with reference to the tide level is the character of the outlet. As far as possible the trunk should be completely submerged a few inches below mean low tide. This is done for two reasons: First, to prevent floating débris from interfering with the closing of the shutter, and, secondly, as a protection to the wood of the box, periodic wetting and drying having a tendency to rot the wood. This is not always practical, however, as a trunk below the level of the bottom of the ditch, on either end, will fill up with mud to the level of the bottom of the ditch, interfere with the closing of the shutter, decrease the cross section of the trunk, and reduce its capacity.

The gate in operation on the main drainage canal in the west-side lowlands might be called the barn-door or canal-lock type. The gate was installed several years ago but was not functioning at the time control measures were started in Savannah. This type of gate is not entirely satisfactory. The weight of the gates alone prevents quick action on the change of the tide, considerable water passing through before the pressure is strong enough to close them. The gates are constructed of plate steel reinforced by iron rods connected by turnbuckles to prevent warping, and are bound on the top, bottom, and sides with 10 by 10 inch square timbers. The side walls and bottom of the flume are of concrete. At the outlet end of the flume the bottom is shaped like a flattened inverted V, the apex pointing down stream. The concrete bottom, being raised about 10

inches above the bottom of the creek, acts as a jamb for the gates to close against. The gates are hung on heavy wooden hinges fastened into the concrete side walls by iron bands.

In the Hutchinsons Island drainage project (an abandoned rice field across the Savannah River and on the north side of the city) two Calco automatic tide gates were installed. The trunk is a section of corrugated iron pipe fitted with the Calco gate at the outlet end. This type of gate is much easier to install than the old rice-field trunk and gate, and the fact that there is no wood about it to rot makes it a very desirable type of gate to use in malaria-control work.

The areas controlled and drained by these tide gates were prolific breeding places for mosquitoes. As early as March both *Anopheles* and *Culex* larvæ were found in abundance in these fields. After the fields were drained and the water confined to the ditches, tide gate and fish control solved the mosquito problem in the area this season.

I think these pictures will show more about tide gates than I can in a paper. They show the conditions before and after.

Mr. LE PRINCE. The next paper will be "Organizations helpful in sponsoring campaigns," by Mr. Clarke.



FIG. 10.—BARN-DOOR TYPE OF TIDE GATE, OGEECHEE CANAL, SAVANNAH, GA.



FIG. 11.—OLD RICE FIELD TYPE OF TIDE GATE, SPRINGFIELD CANAL, SAVANNAH, GA.

ORGANIZATIONS HELPFUL IN SPONSORING CAMPAIGNS.

J. L. CLARKE,

Sanitary Engineer, International Health Board.

There are no organizations helpful in sponsoring antimalaria campaigns. Local organizations should be called upon only to aid in carrying out the program, after it has been accepted by the city government. A local organization should never be permitted to sponsor a campaign, for this initial act implies that this particular organization is to have the credit, the honor, and the glory of having proposed a work which will meet with the hearty approval of the citizens at large. Such procedure would be an implied rebuke to the city officials for their inactivity in things pertaining to the welfare of the city. It would be resented by them and would cause an irreparable breach. The official health agencies are the only true sponsors for antimalaria work. The Federal Government has assigned its part of this work to the Public Health Service which co-operates with the State departments of health. The representatives of the State board of health then should deal directly with the officers of the city where it is proposed to carry on antimalaria work. It is proper to ask permission of the mayor to make preliminary surveys and estimates of cost. If the project be not feasible, it should be so reported. If good results can be had, the mayor should be requested to call a meeting of the council and there the matter should be presented as a cold-blooded business proposition, and to this end charts and other statistical data now in the hands of the Public Health Service and which represents its past experimental work, should be so prepared as to present these facts in a forceful manner; this would be a great aid to the field directors. It must be remembered that the mayor and councilmen have been elected by the people—they control the city funds, they have the deciding vote, they are responsible to the people, and they are the only ones who can enter into contract with the State board of health. They only should have the full credit for having put over a movement which is to gain favor among the voters.

Should the proposition not find favor among the councilmen, the director's first thought is to take the matter up with some local organization and fight the proposition through. This is dangerous business; it is a waste of time. Very often civic organizations are the outcome of forces opposing those in office. They are antagonistic.

By lining up with such organizations you might master strength enough to force the proposition upon the council, put it over in pomp and glory; but this done, trouble will have just begun. Enthusiasm dies and the crafty opposition with whom you would have to deal can so arrange to postpone, to table, and by various means to let the proposition die a natural death before it has gained sufficient headway to prove its merits. This to the people means that the work has been an utter failure, while if it had been the true wish of those who control the city money it would have been successfully carried out.

This is not idle talk, nor is it without foundation in fact. Experience has taught me that if a thing can not be accomplished through natural laws, there will be a reaction. I can recall no less than five engineering projects, which I proposed to the city council of my home city. Each one had a local organization as sponsor and each one failed. I have seen as many go through because some member of the council presented the scheme. Whether or not it was his own matters not; the point is it came through the proper channel.

I do not mean to speak disparagingly of these auxiliary organizations in city government. There is a place for them and a duty for them to fulfill. Their duty is to aid in carrying out the program, not to sponsor it.

Each organization should be carefully chosen to carry out that particular phase of the work for which it is best fitted. The woman's civic league should be instructed in the care of home premises and aid in the disposal of artificial containers. The chamber of commerce should call attention to the economic importance of malaria control in dealing with business prospects and advertise the work in all printed matter put into circulation by them. The Boy Scouts organization, or the school children, should be by all means taught the field work of malaria control. They will carry it home to their mothers and fathers who will listen with interest, for the boys can present the subject in a manner more fascinating than we can. The newspaper can not be termed an organization in the sense spoken of here, but should be mentioned because of the valuable aid it renders throughout the work. It outlines the campaign in the beginning, it publishes the progress from month to month, it sums up the results, and points out the necessity of continuing the work from year to year. Moreover, it carries the propaganda to nearby towns and this paves the way for similar work in these towns for the coming season. The farmer reads the news and applies the principle to his home surroundings; in this way we may extend the work to rural districts where it is more vitally needed. The local Red Cross unit can render valuable service in taking the malaria history census. Of course, it would be better to have one person well versed in the matter, who knows how to bring out the desired information, do this

work in each town in the State. This would insure uniform results and would tend to eliminate in a great measure the personal equation which enters into census taking where several persons are employed. But until the State board of health can furnish such persons, the duty of census taking must be intrusted to the local Red Cross unit and be supervised by the local health officer.

This concludes organizations within the city limits, but the work of malaria control must go beyond the corporate limits of the city. Possibly just outside there is a large manufacturing concern on whose premises a splash dam, a reservoir, or fire-protection barrel gives rise to mosquito breeding. The conditions should be reported to the management with the request that a representative of the concern meet with the city council and determine its portion of the cost of control measures. Large industries are quick to realize the importance of the work and their support is worth while.

So also within flight range of the town there may be borrow pits along the county highway which endanger the health of the community. These danger points were created by the county and should be remedied at its expense. The representative of the city council should be appointed to meet with the county board of supervisors and ask for financial aid or that the existing condition should be corrected by the county road force. The proposition should be explained to the supervisor representing that particular city, and he should be allowed to present the matter to the board.

Often railroad embankments impound water and railroad drainage ditches are not kept in order. In some instances, where no great amount of work is necessary to correct these defects, the section foreman will gladly do the job; but if a large sum is involved, the matter should be taken up with the Public Health Service representative assigned to this railroad, or with the proper railroad official.

There is one other organization which I have not mentioned, and it is a most important one. I daresay it has destroyed more mosquitoes than have been destroyed by the combined efforts of all agencies working toward the prevention and control of malaria; and strange to say the elimination of mosquitoes was not the main object, but rather a by-product. This organization is the drainage district. Public health is mentioned only in the preliminary proceedings merely as a motive to gain recognition by the court; after which brief mention, the question of public health is dismissed and assessments made upon the basis of agricultural benefits to accrue. Notwithstanding the general good accomplished by drainage districts, we find that in specific instances minor drainage or certain other requirements are necessary to eliminate mosquito breeding in drainage canals. To this end we must ask the drainage commissioner to co-operate with us in putting on the finishing touches.

In conclusion I would say the city government should be extended every courtesy possible; consequently, don't let any local organization sponsor your campaign but make a direct appeal to the city council in behalf of your State board of health, being mindful that it is the city council to whom the State board of health will look to carry on the work after the first year's demonstration, and that it is the State board of health upon whom the city council will depend for guidance in after years. Therefore, any act which might tend to create friction or give offence, should be punctiliously guarded against. If, after having presented the offer of State aid and having worked assiduously to gain their favor, your offer is refused, then abide by their decision and pass to the next town. But before leaving, by all means assure them that the State board of health is ever watchful of their interests and is ready and willing to cooperate with them at any time in matters pertaining to the health of their city.

DISCUSSION.

MR. LE PRINCE. The paper is open for discussion. Mr. Komp.

MR. KOMP. I would like to take friendly issue with Mr. Clarke. We have both been working in the same State, and my ideas are diametrically opposed to his.

The city councils in both my towns were lukewarm in regard to malaria work. It was only because I managed to get the support of the woman's club in Columbus, which, by the way, is one of the sponsoring organizations, that I was able to put the thing over at all. The city council will not do anything usually unless they think the people want it.

MR. LE PRINCE. Do you believe, Mr. Komp, that the women's organizations, if they are sufficiently interested, could probably get us the funds we are looking for?

MR. KOMP. Yes, sir; they did in Columbus.

MR. STROMQUIST. I agree with Mr. Clarke that the value of these organizations is more in promoting and establishing a campaign than in carrying it out afterwards. Of course, you must first get the city council interested and get these organizations to go before the city council.

In one town the business men's club and in the other town the Lions' Club pledged half of the funds and got the city council to put up the balance. At one time the leading banker got up and said the city didn't have any money, but he said it ought to borrow, beg it, or steal it, but to get it.

MR. MAGOON. Mr. Chairman, I think it is essential that you go first to the mayor, who is the chief officer of the town, and then make the next call on the health authorities that may be there, but

let the mayor know your mission, and get him to ask you to study conditions and advise him regarding the situation. The mayor usually refers you to organizations that may be helpful.

You assume considerable responsibility when you try to get the woman's club or other organization to force the mayor and city council. I think it best to have the mayor and city council know your purpose before appeal is made to other organizations.

MR. WOODFALL. Mr. Chairman, I do not quite agree with Mr. Magoon on this matter. I believe in going into a city or town to make a malaria survey the first man that should be seen is the local health officer. If you ignore this man at first, you are going to have trouble from start to finish, as after your work is completed it is the local health officer who must carry it on. It is the local health officer who should introduce you to the mayor and members of the city council.

I have found in several cities that the part-time health officer sits on a high throne and he must not be ignored.

DR. FRICKS. Gentlemen, in my judgment, Mr. Clarke has quite clearly defined the difference between the proper sponsors of an anti-malaria campaign and the assistants in such a campaign. The legally constituted health authorities are the true sponsors for work of this character, and the Public Health Service can legally cooperate in health work of any kind only with the legally constituted State and local health authorities. Now, when it comes to securing local assistance and stimulating favorable local sentiment for malaria control, we all realize the importance of securing advice and help from local organizations—woman's clubs, chambers of commerce, etc. Assistance from these sources can never be wisely neglected, but the method of securing it must be left to the judgment and tact of the sanitary engineer in charge of the work.

MR. LE PRINCE. Does Mr. Clarke wish to make any further remarks?

MR. CLARKE. Only one thing. It is proper to get the support of these other organizations if it be requested of you by the mayor and council to determine the sentiment of these organizations, but otherwise you have got to abide by the rulings of the people or the officers the people elect. You can't afford to create any harsh feelings between those in power and the State board of health. I might say that even though a campaign is supported by outside parties, enthusiasm soon dies, and the funds might by some means be curtailed or misappropriated, and you would be shut off without any funds whatever, so you had better stick close to the council and the mayor.

MR. LE PRINCE. The next paper will be "Foreman and labor problems," by Mr. Lenert.

FOREMAN AND LABOR PROBLEMS.

L. G. LENERT,

Assistant Sanitary Engineer, United States Public Health Service.

The plans and methods of procedure discussed at this conference will naturally be helpful to one and all of us, yet I feel that no matter how complete the plan devised or how efficient the methods employed, the success or failure of malaria control depends chiefly upon its proper execution. The personal equation is really our most important consideration. The effective direction of labor and the interest manifested in the work are vital factors of success.

In any line of endeavor one must be interested in his work, but in the control of malaria there must be more—there must be enthusiasm and a determination to conquer at all odds. There must also be that spirit of optimism, as Mr. Le Prince once explained to me, of never becoming discouraged, no matter how gloomy the outlook. This is not the natural disposition of one out of ten of the men one is able to secure at the salaries and wages at one's command.

For purposes of economy and also for the additional and very important purpose of tying the work to the ordinary activities of municipal administration, the selection of a director already on the pay roll of the community would seem wise. We must not be misled, however, by false ideas of economy. Sometimes we are successful, but the chances are that instead of securing a valuable field marshal one more often finds he has a very poor lieutenant who will depend on the buck private to do his work.

In most of the communities in Texas where malaria-control operations are being carried on, the economical handling of the work will hardly permit of employing more than one full-time man for the entire season. Additional assistance will perhaps be required from time to time, but the work will depend chiefly on the full-time man. He must be a combination of foreman, inspector, oiler, laborer, and must understand and put into operation the methods of fish control. Such a combination is not met with in every community. Where it can not be found a part-time foreman and inspector is selected to supervise the work of a laborer who must, due to the nature of the operations, spend most of his time alone.

The results are very seldom what they should be, because this arrangement places too much dependence on the laborer, and the part-time foreman and inspector is very apt to be away when his services are most needed.

A better plan to follow would be to combine the wages of the laborer and the salary of the part-time foreman and secure one man to be held responsible for all results obtained, depending upon him to do all inspecting, oiling, and fish-control work personally. Where this man has been previously schooled in the work very good results can be had. I would like to mention a plan suggested and carried out to a certain extent in Texas during the past season. The town of Cameron was very desirous of putting on an antimalaria campaign, but could be assured of very little financial assistance either from the State board of health or the other cooperating agencies. It was suggested, however, that if the town would send a man to one of the units already in operation to learn the methods employed it would be possible to extend advice and general supervision of the work to Cameron. A man was sent to one of the units for education. After two weeks of instruction and with an occasional visit from the sanitary engineer in charge he was able to accomplish very good results. I might mention that this man did not hesitate to apply himself to this work in all of its phases, including carrying the Meyers knapsack sprayer.

The people of Cameron are more than satisfied. The work was begun late in the season and was considerably hampered by a shortage of funds, but the results obtained will more than justify the expense; and the town will continue the work during the coming season.

The training of men to carry on this work in small communities, at one of the units where intensive control work is being instituted, is to my mind one of our best methods of expanding this work to the largest possible population. The plan to be followed, including methods of procedure, must of necessity be obtained from an experienced field man, generally the sanitary engineer.

The knapsack sprayer may possibly be an item of equipment, and as such seems to have no place in this paper, but it has a very direct relation to our labor problem. I haven't the remedy to offer but it has been my chief obstacle in securing competent labor. In the city of Monroe, La., no less than 30 men were employed and more than a month's time consumed in training them before three men for permanent oilers were finally obtained. These were not men of especial fitness for the place but such as could be secured. White labor was tried but not kept long, due to the spilling of oil on their clothes and bodies. The only consideration which enabled us to keep our oilers was the 25 to 50 cents increase in the daily wage. A better method

of oiling should be devised or improvement made in the Myer's knapsack sprayer.

Trained men are necessary in this work and it is important that the employment of both foreman and laborers be permanent in order that the following season can be properly taken care of. The form that this permanent employment must take will not be the same in every community. A large town which can support a health department will probably be able to use the men in sanitary privy construction or other sanitary lines. The problem will be the small towns—how to retain the force in municipal lines during the inactive season. This is one of our principal problems, and though each individual community will present its own particular difficulties, the experience of those present will no doubt be helpful to all.

This retention of trained men is one of our chief concerns, and while the instruction of the people in general is very important and the success of the work is largely dependent on this, I feel that it will always be necessary to have men to actually see that the work is carried out—men who are trained in all phases of the work and alive to grasp any new developments which may come to hand.

DISCUSSION.

MR. LE PRINCE. Any discussion?

MR. PARKER. I think it has been mentioned before, but in connection with labor I think it should be emphasized that the construction work of antimalaria campaigns should be done in the winter months before the active mosquito season sets in. In agricultural communities, such as most of us are operating in, that is the time when labor is most plentiful and when it can be obtained for the lowest possible wage. I think that will eliminate the high cost of labor experienced during the past year, in communities where they were paying excessive prices for cotton chopping, work in the mills and gins, and so forth.

MR. LE PRINCE. That point is well taken.

MR. KOMP. I think Mr. Parker's suggestion is a very excellent one. In most of the territory in the South in which our work is done, the greatest rainfall occurs in the winter and spring months, with the dry season in late summer and autumn. From about the latter part of August on there was no standing water anywhere in my towns, even large swamps and wet-weather streams going dry. The effectiveness and economy of our work could be increased if most of the drainage work were done during this dry season, rather than during the spring and early summer, when the ground is covered with water. Maintenance expenditures would doubtless be increased, but would

be compensated for by the decreased cost of ditching unhampered by mud and deep water. If possible, also, fall campaigns in certain places could be arranged to begin immediately after the cotton crop is picked, when there is no outside demand for labor. With more abundant, and consequently better labor, working on dry land, unhampered by boots, which are an important item of expense, I think our results would be much more satisfactory than at present.

Mr. LE PRINCE. The next paper will be "Malaria statistics" by Mr. A. W. Fuchs.

MALARIA STATISTICS.

A. W. FUCHS.

Associate Sanitary Engineer, U. S. Public Health Service.

A knowledge of the prevalence of malaria is essential in antimalarial work. First, it serves as a guide in the selection of places for campaigns. Where malaria is scarce the appropriation required for control measures may be so large as to be unwarranted in view of the limited results attainable. Again, where for some reason or other the choice is limited to one of several towns, preference should be given to that place where the cost of control will be a minimum per case of malaria. Secondly, it affords a measure of the effect of anti-malarial campaigns, not only from year to year, but from month to month during the period of control. Most important of all it is of paramount importance in establishing the need of appropriations for contemplated work and in justifying the investment made in work already undertaken.

Malaria figures may be obtained from State or county morbidity files, from physicians' reports of the percentage of their practice contributed by malaria and of the number of cases or calls for malaria, from a malaria census, from prescriptions for malaria on file at drug stores, from claims and benefits paid for malaria by industrial and health insurance companies, from sickness records at mills, and from absences from school on account of malaria.

State and county morbidity records, because of their easy access, would be ideal sources of malaria statistics were it not for the unfortunate fact that very few States require malaria reporting. To be sure, the returns from this source are incomplete during the first few years, but the sooner such reporting is made compulsory in each State, the earlier will reliable figures become available for future use. It should be the policy of State health officers in those States where malaria is a serious problem to obtain legislative provision for adequate malaria case reporting. As there is no such data available for North Carolina, where I have done most of my malaria work, I shall refer to Dr. Leathers's paper read at the convention of the Southern Medical Association at Louisville, Ky., November 15, 1920, for a further discussion of this subject.

In the absence of State and county reports it is natural to turn to the practicing physician for such information. Estimates by doctors of the percentage of their practice during the summer and fall contributed by malaria constitute a preliminary guide to the desirability

of an antimalaria campaign. At Goldsboro, N. C., these estimates varied from 10 to 75 per cent, and averaged 28 per cent for the five doctors interviewed. Dr. Rankin raises the point that if similar percentages were obtained from the doctors for all the common diseases the total would often be above 100 per cent. As I have never tried this, I am not in position to deny his statement. However, the estimates made by Goldsboro physicians were later closely substantiated by figures submitted by three insurance companies whose records showed that during 1919 the claims paid for malaria constituted 22 per cent of all claims for sickness paid by these companies in Goldsboro.

Physicians' current case reports are not nearly so difficult to obtain, especially if solicited at intervals, as records for past years. It is easier for the doctor to promptly record a case just visited than it is for him to search his records for cases occurring during an entire year past, and he naturally balks at such a task. It would seem best, for the sake of better cooperation by physicians as well as greater accuracy in records, to arrange for the doctors to start their malaria case records a year in advance of an antimalarial campaign. Instead of necessitating a lengthy search through an entire year's daybook or account book, or worse still his memory, for names of patients who to the best of the doctor's recollection were treated for malaria, such a plan would make available accurate records with little trouble to the doctor. In the cooperative towns of North Carolina only one-fourth of the doctors kept individual case records for 1919, whereas during 1920 case reports were obtained from over three-fourths after they had been supplied with proper forms and impressed with the necessity for records. The following table illustrates this difference in the value of the figures for the two years:

Malaria cases reported by doctors at Goldsboro, N. C.

Month.	1919 total.	1920 ¹			
		Probably contracted elsewhere.	Previous history positive.	New local cases.	Total.
January.....	3				
February.....	4				
March.....	5				
April.....	7		2		2
May.....	9	1	4	5	10
June.....	17	1	2	4	7
July.....	71	1	8	2	11
August.....	137	4	3	5	12
September.....	162	5	3	13	21
October.....	127	1	7	4	12
November.....	95				
December.....	6				

¹From Jan. 1 to Oct. 13.

In the above table, as well as in the chart representing the table graphically, the 1919 cases of only those eight doctors who also reported their 1920 cases are included in order that a proper comparison between the two years may be made. Thus, there was a

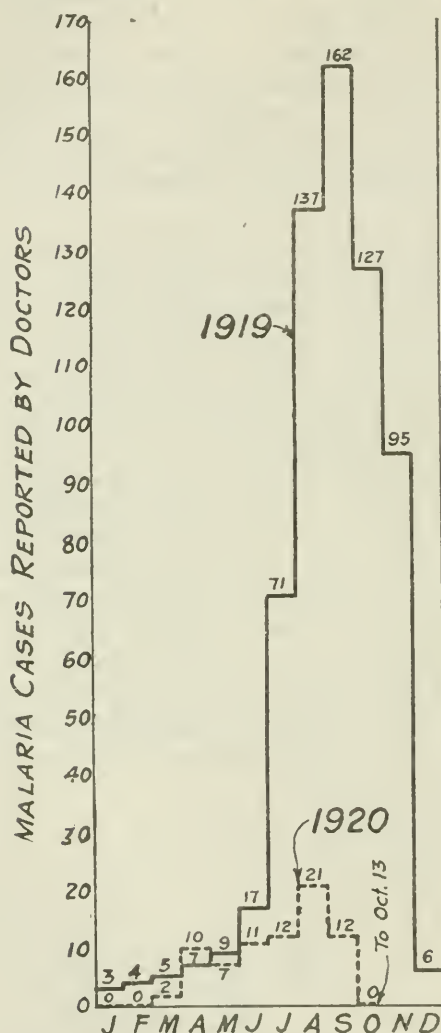


FIG. 12.—Malaria cases reported by months for 1919 and 1920, Goldsboro, N. C. (Cases reported by 67 per cent of all physicians.) A. W. Fuchs, November, 1920.

total of 75 cases from January 1 to October 13, 1920, while for the same period in 1919 there had been 470, or a reduction of 84 per cent. The value of individual case records giving histories of the cases, as summarized for 1920 in the above table, lies in the clue provided as to the success or failure of control measures, for the occurrence of chronic cases or of cases contracted elsewhere is not to be credited to the failure of the control work. Furthermore, the collection of reports at frequent intervals will serve as a check on the satisfactory progress of the work, as an unduly high report will point immediately to a weakness in the control, which may be rectified without delay.

The cases for 1919 were obtained by personal calls on the doctors. For the 1920 cases printed forms were first mailed, and the doctors were requested to supply the name, address, age, sex, color, date first seen, length of residence in town, and date of last previous attack for each case. Few of the doctors gave all this information, in fact

some did not enter their cases on the forms until they were personally called for; but on the occasion of such call the doctor was asked for a history of each case with reference to places of residence during the month immediately preceding the attack, and also to its acute or chronic character. It is significant to note that

a number of personal calls, in some cases half a dozen, were made on the doctors before their 1919 cases were obtained, while later those for 1920 were received usually on the first visit. There is no doubt that the mailing of requests to the doctors for their cases placed them on the defensive when the data was later called for in person.

While information for past years obtained from the doctors' case records, day book, account book, or from memory, as the case may be, is not 100 per cent accurate, it is often the best, sometimes the only information available. I have found them more reliable in North Carolina than returns from malaria censuses. The important point to remember is that the reliability of such data depends on the percentage of doctors reporting. Figures obtained by applying to all the doctors the average number of cases reported by 10 per cent of the local physicians may be questionable, but averages of reports from 70 per cent can not be far wrong in estimating the total number of cases treated in a town.

Returns from malaria censuses may be reliable under certain conditions, but our experience in North Carolina has been discouraging. At Goldsboro, the population of which is 11,300, two separate censuses taken by different persons but for the same year gave returns that were far apart. The first, taken in December, 1919, by four members of the woman's club, and covering 6 per cent of the population, showed positive histories for 1919 in 21 per cent of the persons interviewed; the second, taken two months later by two men from the State board of health, and covering 17 per cent of the population, showed only 3 per cent positive histories. An investigation of this decided discrepancy was made by selecting homes visited in both censuses and by revisiting these places in company with the women who had taken the first census. It was found that in some instances the persons interviewed, all whites, admitted having correctly reported cases to the woman census taker, with whom they were acquainted, but having deliberately lied to the men, who were strangers. The motives that prompted such action were evidently a dislike of publicity, a disinclination to supply the information to strangers, and possibly a vague fear of quarantine. In another instance the woman census taker had made returns that were inaccurate, purely out of zeal for the antimalaria campaign. The investigation showed, therefore, that whereas in some instances the women's returns were correct, in others they were too high; also that the men's figures were too low. But there was no way of arriving at the correct figures from these returns.

But census taking in colored sections we found even more difficult than among whites. Out of 50 homes visited in Little Washington, a colored district of Goldsboro, only two positive histories were

obtained. Yet one negro doctor reported treating 350 cases of malaria in Little Washington during 1919. The darky is by nature secretive regarding such matters and entertains a fear of quarantine or vaccination in spite of all explanations to the contrary. On a number of occasions I have managed to obtain frank reports from Negroes by explaining that I was anxious to find out whether they were bothered with mosquitoes and malaria, and that if there were enough to warrant it, we would undertake work to get rid of them.

Malaria census data have the disadvantages, compared with doctors' reports, of being more difficult to collect and of not being available until after the end of the year. Where they can be reliably obtained they have the advantage of revealing all cases of malaria, while the doctors' reports take no account of cases that are "home treated." But for satisfactory census returns the census should be taken immediately after the end of each year to eliminate errors of memory; it should be taken by the same person for successive years to avoid differences due to personal equation; it should be taken preferably by a trained local nurse who is acquainted locally and who can recognize a history of malaria.

The use of doctors' prescriptions on file at drug stores as a measure of the prevalence of malaria was attempted at Goldsboro immediately after the inadequacy of the census returns became apparent. The prescriptions were examined by a young physician detailed by the State board of health, and the data were compiled by myself. Because of the tremendous number of prescriptions on hand, only those filled during the four summer months from July to October, 1919, were examined. The results obtained in the two drug stores visited were remarkably close. Out of 3,219 prescriptions examined 125, or 4 per cent of the total, were for malaria treatment. Prescriptions considered as indicating malaria were those in which more than one-half of the active ingredients consisted of quinine and those for Warberg's tincture and for Vinatone and Febritone, proprietary remedies prescribed by some of the local physicians for malaria patients with intolerance to quinine. Only prescriptions by resident doctors were included. If the average for the two drug stores visited be applied to the 10 drug stores in Goldsboro the total number of malaria prescriptions would be 625. It must be remembered that this figure takes no account of verbal prescriptions for antimalaria treatment or of "home treated" cases. This source of data, therefore, can not supply information covering the total prevalence of malaria. But for the purpose of arriving at the comparative prevalence from year to year and for measuring the percentage reduction due to antimalaria measures, an examination of prescriptions will give reliable results because errors of memory and those due to personal

equation of the investigator are eliminated. Furthermore, this source of data is available on short notice whenever desired.

Where the records of industrial and health insurance companies are available the data is reliable because no claims are paid without medical examination. The local insurance agent will seldom have the desired records in proper shape, but the home offices will usually have them on file. Most companies appeared willing to submit information when assurance was given that the identity of the records would be considered confidential. An idea of the possibilities, also the limitations, of this source of information may be obtained from the following table:

Insurance companies' reports of malaria for Goldsboro, N. C., 1919.

Insurance company.	Malaria claims.	Malaria benefits.	Total claims all causes.	Total benefits all causes.	Total policy-holders.	Percent-age malaria claims of total claims.	Percent-age malaria benefits of total benefits.	Percent-age malaria claims of total policy-holders.
A	79	\$320	682	\$2,803	2,096	11.6	11.5	3.8
B	1 312		1 518			56.8		
C ²								
D	65	294						
E	95	235	939	2,964	1,625	10.1	7.9	5.8
F ³								

¹ For 6 months ending March, 1920.

² Keeps no separate records.

³ No reply.

The information requested included malaria claims, malaria benefits, total claims for all causes, total benefits for all causes, and total number of policies in force, by months for 1919. The above tabulation shows how much of this data was submitted. Of the six companies consulted, two gave all the figures, two submitted partial data, one kept no separate records for different towns, and one made no reply. The number of claims paid for malaria varies from 10 to 56 per cent, averaging 22 per cent, of all claims paid for sickness. The relation between malaria benefits and total benefits, for the companies that presented these figures, is approximately the same as that between malaria claims and total claims. It is interesting to note that claims for malaria were paid to 5 per cent of all policy holders. It was expected that this figure would represent the percentage of the city's population having malaria, but it is evidently less than the latter, because some malaria cases do not apply for claims, particularly in light attacks, while chronic cases having no acute attacks probably receive no benefits. It seems, on the whole, that if all insurance companies operating in malarious sections were impressed with the benefits they derive from antimalarial work, better cooperation would be obtained from them.

At the large mills where adequate medical supervision is provided records may be available showing malaria cases, time lost on account of malaria among employees, and increased production following malaria-control operations. Such is not the case in the demonstration towns of North Carolina.

Absences from school on account of malaria constitute an impressive argument for malaria control before women's organizations. At Farmville, N. C., school records of absences were looked up, and notes were sent to the parents of the absentees requesting them to indicate absences due to malaria. Out of six grades with a total enrollment of 178 pupils, 47, or 26 per cent, had been absent because of malaria between October 1 and December 31, 1919. For the 24 cases in which the length of absence was reported the accumulated absences totaled 261 days, or an average of 11 days per case.

The need of more data of this kind is urgent because of its value in support of antimalaria appropriations. Were representative figures at hand it would be possible to present convincing financial statements to those business men to whom the mere prevention of disease and distress makes no such strong appeal as the promise of large dividends on an investment. It could then be shown, for example, that at Goldsboro the reduction of 84 per cent in malaria cases meant a saving of 810 cases in 1920; that each case of malaria among working people represents two visits by the doctor at a cost of \$4; a loss of 11 days' wages, at \$4 a day, making \$44; \$1 for medicine; or a total of \$50; that one-half of the cases thus prevented would have occurred among workers; and that the resulting saving of \$20,250 to the citizens of Goldsboro represents a dividend of over 300 per cent on the city's investment of \$5,026 for malaria work in 1920. Of course, such a statement does not show the loss in curtailed production for the manufacturer, in smaller volume of business for the merchant, in diminished freight for the railroad, in reduced real estate values and rentals, or in any of those factors which stunt the economic growth of a community, but to which definite cash values can not be assigned.

How do the malaria figures from different sources compare? At Goldsboro the average of the two 1919 malaria censuses indicated that 12 per cent of the population had malaria; doctors reported that 966 cases, or 9 per cent of the population, were treated for malaria; drug stores showed 625 malaria prescriptions, or that 6 per cent of the population had prescriptions filled for malaria; and insurance companies indicated that 5 per cent of their policyholders received benefits on account of malaria. When the figures for 1920 are available, it will be interesting to compare the percentage reductions derived from the different sets of data.

In conclusion I would urge that State health officers obtain and enforce legislation for State-wide malaria reporting; that doctors be supplied with forms and requested to keep malaria case records beginning with the year preceding control measures; that malaria censuses be taken for successive years by a local trained nurse; that better cooperation be obtained from insurance companies; and finally that each man present make every effort to collect data showing economic losses due to malaria in such mass that representative figures will eventually be available.

Mr. LE PRINCE. The next paper will be "Surveys and maps," by Mr. Buck.

Mr. BUCK. Mr. Chairman, although my subject is surveys and maps, what I have to say is chiefly concerned with a discussion of what Mr. Fuchs has already mentioned in his paper on "Malaria statistics."

SURVEYS AND MAPS.

C. E. BUCK,

Sanitary Engineer, International Health Board.

Surveys and maps form the foundation upon which the malaria-control demonstration work is to be built. Since the time is altogether too limited to present the entire subject, I shall confine myself chiefly to the discussion of what I believe to be the cornerstone of this foundation—the securing of an accurate malaria index.

The object of our demonstrations is to prove to the people in the various States in which we are working that in an urban community malaria can be eliminated and at a cost which will insure an actual economic saving to that community. How are we to prove to a city council that we have effected a saving for their city unless we know what the malaria status of that city is and has been?

Granted that we must know this, how shall we go about getting that figure? The general methods of getting a malaria index are familiar to us all, and it is hardly reasonable to suppose that any brand new method can be devised, yet I believe that we can make better use of the tools with which we are already working. There is no single method or, for that matter, any combination of methods which will give us an absolutely accurate figure. It is, however, probable that some sources of information will give us a figure which is correct within certain limits, say a few per cent. It is for us, then, to take the means by which we can arrive at the more nearly correct figure, to avoid such mistakes as can be avoided, and to correct for, in so far as we are able, the unavoidable inaccuracies.

In order to make clear some of the difficulties which we encounter, let us discuss for a moment the various sources of information which we are at present using in the establishment of such an index.

In the malaria census made by a house-to-house canvass we can, of course, avoid the errors which would inevitably result from taking too low a percentage of the population or from confining too large a percentage of our interviews to one particular part of the community. Naturally the more evenly we distribute our interviews over the entire community and the larger the percentage of the population we take the more reliable will be our figure. The question may well be asked, How low a percentage of the population can be included and still give us a dependable result? It seems to me that it depends very largely upon the size of the town. For example, 10 per cent of a city of 10,000 would probably be ample, whereas it would obviously be unfair to depend upon results obtained from only 10 per cent of a town of 200. Would it not be well for us all to come to some

agreement as to the minimum percentage which could be taken in towns of varying sizes, and still give us fairly accurate results?

By whom should such a census be taken? If taken by some local organization such as the Woman's Club, civic league, or high-school students it is found that the resultant figure is often too high. This is particularly true in a community where the people are anxious to have the work done, and in their zeal to have the program go through exaggerate the amount of malaria which exists. On the other hand, local organizations often fail to interview many of the Negroes, who usually live on the outer edges of town, where malaria is most prevalent, with the result that in this respect their figure is too low. Thus from one cause we appear to get too high a percentage and from another too low. Will these inaccuracies in opposite directions tend to make the total result fairly nearly correct? It is, I think, doubtful, and where there is no particular anxiety on the part of the people toward taking up the work we shall probably get a figure which is too low.

When the census is taken by trained men, usually outsiders, we seem invariably to get too low a percentage of infection owing to the fact that people are loath to admit to outsiders that they have had malaria. Negroes are particularly prone to say no to any questions regarding malaria for fear that an affirmative answer will lead to vaccination or quarantine.

Doctors' reports will, I believe, give us the most reliable figure upon which to base our estimate of savings which will accrue to a community as a result of getting rid of malaria. But the question naturally arises as to what percentage of the doctors it is necessary to get reports from? May we take 50 per cent, or must we have 75 or 80 per cent? This would depend upon the number of doctors. If we had 20 doctors and got reports from 10 of them it would probably be justifiable to use these figures. If, however, we have two doctors and only one of them reports it is doubtful whether his figures would be representative of the whole community.

What shall we do with the doctors from whom we are unable to get reports? Shall we disregard them altogether; shall we assign to each one the average number of cases as represented by the reports of the other doctors in the community; or shall we assign to each the lowest number of cases reported by any of the doctors? It would seem to me to be fair to count each one as having the average number of cases. Let us try to come to some agreement as to the policy to be adopted in this case as well as in all other cases in which there could be any doubt as to what policy to pursue.

Although every effort should be made to get cases of malaria, and only such cases as occurred within the corporate limits, it may in some instances be impossible to get anything better than total calls

for malaria. Where such a condition exists are we justified in assuming that a case of malaria will average two calls and dividing the number of calls by two in order to get cases? I found that it was the general consensus of opinion among about 30 doctors interviewed that a malaria case would not average 2 calls. Of course we ought to have a great many more figures before accepting this as true, but it at least seems reasonable.

What relation exists between the number of cases of malaria as reported by doctors and the total number of cases in the community? It is probable that not over half of the people having malaria see a doctor, but this is merely an assumption. Headquarters should be able to give us some valuable information on this point by comparing the figures of the house-to-house census with the doctors' reports.

Although druggists' prescriptions and records of sales of chill tonics, insurance companies' reports, and mill and factory statistics, may be extremely helpful, and, perhaps, in some communities of paramount importance, in general they can not be relied upon as the chief means of getting a malaria index.

All of this discussion leads us to the conclusion that, although all methods have their inaccuracies, some are more reliable than others; that we are not all using the same method or combination of methods; and that even should we use the same method there would still be a great variation in the way in which we adjusted the information obtained.

It is to be hoped that as a result of this discussion we shall all come to some agreement, both as to the best method to be used in establishing a malaria index, and as to the adjustment of the information gathered by this method.

It is my personal opinion that doctors' reports should be adopted as the means of securing the index. Although subject to certain inaccuracies and not giving us the actual amount of malaria, they will give us a minimum malaria index which is practically indisputable. With doctors' reports as the basis of our figure we can say that we have at least so much malaria, probably a great deal more, but certainly not less.

As to the policy to be adopted in gathering and adjusting the information, I believe that we ought to have at least a majority of the doctors reporting; that we are justified in assigning to doctors failing to report the average number of cases as reported by the other doctors in the community; that every effort should be made to get cases of malaria, and only such cases as occurred within the corporate limits, but where we have only calls it should be permissible to divide the calls by two in order to get the cases. Beyond this, if we are to keep our figure in any way reliable, I do not believe it wise for us to change the figures as reported.

Just one more point which Dr. Rankin wanted brought up. How high a percentage of malaria must we have in a community in order to justify our going ahead with a malaria-control demonstration? Personally I do not believe it depends upon percentage at all. It seems to me that it is a comparison of the cost of malaria to a community with the cost of getting rid of it which will determine our decision. This brings up the question of how much does a case of malaria cost a community? If we could get some reliable statistics on this cost it would be very simple, with the number of cases and the estimate of the cost of the work before us, to determine very closely what savings we could effect for any given community.

DISCUSSION.

Mr. LE PRINCE. Dr. Bass, after extensive investigations in Mississippi, says he found that about one out of every five cases in the colored population sees a doctor.

Mr. JOHNSON. My doctors didn't sign up either. I told the State health officer in July that I wasn't getting these reports. He said, "Oh, I think I can get them for you, and I'll do it." But he hasn't had much more success than I did, and recently told me it just couldn't be done. If the State health officer can not get them to make these reports, how much effect do you think the pleading of an engineer will have?

I don't want you to think that I am degenerating into a mere attack on doctors. Our Alabama doctors have supported the work magnificently this year, and have given of their time and efforts unstintingly. I believe the success which has attended the work is due to them perhaps more than to any other one cause. But the very doctors who have helped the most are the ones who simply will not report cases. We can not rely on using the cases reported by the doctors as the index of the amount of malaria in Alabama, for if we did we would be forced to the conclusion that there was practically none of the disease in the State and that malaria control work there was needless. I think we all know that such is not the case, and we must gauge the amount of malaria in Alabama by some different method.

Mr. STROMQUIST. I wasn't able to get any reports last year or this year. The doctors don't report malaria. The most discouraging part of the work to an engineer is that he can't get data to show what results he has accomplished, particularly to an engineer who is accustomed to dealing with accurate figures.

Mr. LE PRINCE. I would like to ask if there is anybody here who has succeeded in getting statistics that were valuable.

Dr. BARBER. I do not claim to have succeeded in getting accurate statistics of malaria incidence, but I will tell what I tried to do in

one town. Through the cooperation of local physicians I attempted to secure blood slides of cases suspected of malaria before quinine was given. A fair number of slides was obtained, only a small percentage of which showed parasites. Again, we searched for cases by means of a house-to-house canvas and examined blood slides of all cases at all suspicious of malaria. We employed a third method, one which has been mentioned in this meeting, the determination of the percentage of absences from school due to illness. In this town absences due to all sorts of illness during the relatively malarious weeks between the middle of September and the middle of October was only about 3.3 per cent of the attendance. Further, we determined the parasite index of two colored schools. This index, about 5 per cent of nearly 70 persons examined, compared favorably with a school I once examined in the Philippines, which gave nearly 60 per cent positive at one examination.

Dr. FRICKS. I should like to say just one word about malaria statistics. I can't get away from the idea that the State health officer is properly responsible for the determination of the prevalence of malaria in any community within the State. That seems to me to be perfectly evident and clear. Also that the sanitary engineer ought not to be expected to make a survey for the determination of malaria prevalence in any town in which he comes to do drainage work.

I realize some of the difficulties under which you are placed in the field, and that your interest in the work will prompt you to use every method that comes to your mind in determining just how much malaria there is in your community so you can show just what you have done at the end of the season. But I think that the State health officer should furnish information as to malaria incidence in selected towns and is actually responsible for this information in carrying on his part of the cooperative agreement under which we are working.

I agree with Mr. Buck in the statement, which I understood him to make about the doctors' reports, that in the beginning they should be considered as the minimum standard of malaria prevalence.

Now, as to the doctors' monthly reports, I did not hear anyone answer the question as to how many of you were getting such reports. But these reports are provided for in our original agreement—the doctors in each one of the towns should furnish a monthly report of malaria cases treated. Now, understand this is separate from the report that Mr. Buck mentioned as the minimum standard in the beginning, but in carrying on the work all through the season you are expected to get from the doctors in your community a monthly report of malaria cases. I don't know how many of you got those reports; there are some that did, but in case you are not getting

them the sanitary engineers should report that fact to the State health officer, and ask him to assist in carrying out this cooperative agreement that we have entered into.

Mr. MAGOON. Mr. Chairman, I have had the city councils present the matter of malaria reports to each doctor. We have tried to insist that each physician give information each month that would let us know who had malaria. I need to have knowledge of where cases originate in order to control the antimosquito measures. The names of the patients were of value in assisting us to distinguish new cases from old. It is a much better point with the doctor to tell him that you wish data to enable you to learn of outbreaks of malaria so you can guard against further spread, than to try to get figures for statistics that he cares nothing about.

I have practically complete records of physicians' malaria reports for each month beginning last June. But I had to go to each doctor every month in order to get them. Reports giving names of a dozen cases of malaria from neighboring houses in one section of Groveton led us to discover an important *Anopheles* breeding place in a back yard. This was in June. I learned of no new cases developing in this block during the remainder of the year. Prompt control was possible because of the knowledge of the location of these cases.

Mr. OLD. I am glad to hear that some States are in the same class as Georgia with regard to doctors' reports. I have about 25 doctors and I can't get figures from any of them. It is not intentional; they are just not used to figures.

I had an inspector in two towns take a malaria census. He uses the regular malaria census cards to get cases of malaria, and these cards are referred to the doctors for confirmation. In that way I think, I got very good results.

Mr. SHAW. I want to ask a very direct question of Dr. Fricks and Mr. Le Prince: What is the best plan for making maps of the preliminary survey? And do you think it is advisable, at the completion of the demonstration, to prepare a tracing showing all ditches, so that a new engineer, the local man, or even a stranger to the work, can easily locate all water courses with which he will be concerned? I did this in the case of Baton Rouge, showing the block line dotted and the streams and ditches as solid lines.

Mr. LE PRINCE. Not only do I think that should be done but I think every breeding place should be plotted on that map. I am referring to natural breeding places, but you will find later on as you work in different sections there are certain sections where possibly once in six years, say, there will be formed new temporary production areas, but in all cases try to have every known place marked down so the new foreman will understand where his work is.

It isn't essential to push other more important work out of the way in order to make an accurate map, but there should be a map that is sufficiently accurate for practical purposes. Not only should that map be made, but a copy of that map should be left with the local health officer, and a copy sent to headquarters.

Dr. FRICKS. I would like to mention the map that Mr. Johnson sent in with his preliminary survey. It seems to me this little sketch map, showing the town, its location on the railroad, and the drainage and streams, is really valuable. At least, to me it was. I don't know how much time it took Mr. Johnson to prepare those sketches, but I think they were good.

Mr. LE PRINCE. Those sketches served a good purpose, and I think should be made whenever possible. It took only a little time.

Mr. KOMP. Mr. Buck, I think, has had some experience in surveying from airplanes, and he may be able to tell us something about it.

Mr. LE PRINCE. I would like to hear it.

Mr. BUCK. I had a little experience in that line. The field was located on a prairie, and the first thing I did, at the suggestion of the health officer, was to take a flight over the prairie surrounding the field, and I could see the main drainage system very well. I got a mighty quick and comprehensive idea of the main drainage system. Of course, following that I had to make a survey on foot. I think that some one during the war had taken a flight over the territory to map roughly the main drainage system in that section.

Mr. KOMP. During the war I had the opportunity to take some photographs showing the very intricate drainage system on the Mississippi coast. Some seaplanes, attached to a naval recruiting flotilla, were available, and with the permission of the commander I was able to get two dozen very interesting photographs. Even in very heavily wooded swamps the water was visible through the trees, and the photos supplemented our maps to a very great extent.

At one of the local photographers' in Tupelo, Miss., I saw some large aerial photographs of the town taken from a plane by fliers from Payne Field, near by. These photos showed every bit of the drainage system, including some outlying ponds that my foot survey had missed, and from them it would have been possible, without anything else, to make all the maps necessary for the report to headquarters. I obtained copies of these photographs, and intend to incorporate them in my annual report.

Mr. BUCK. I had the good fortune to fly in the Army for a couple of years. During that time we made a good many photographic maps. As you may know, the cameras used on an airplane are so adjusted that at a given altitude a given ground area will be taken. In this way a series of photographs can be put together to make a map the area of which is definitely known. There is no ques-

tion in my mind but that an airplane is admirably adapted to many phases of our work. The use of an airplane is not nearly as expensive as one might be led to believe, and it is my opinion that one could be used advantageously by the cooperative malaria-control agencies.

Mr. LE PRINCE. I will ask Mr. Buck to close the discussion.

Mr. BUCK. Mr. Chairman, I heartily agree with what Dr. Fricks said in regard to the State health officer being responsible for the malaria statistics of his own State. But some of the State health departments haven't the machinery necessary to get that information, and until they get it we must use other methods.

It is perfectly true that the doctors will not send in reports, and the only way we have been able to get reliable reports from them is to go to their offices and sit down with them and go over the records, which is a long and laborious process; but I don't know of any other way of getting them. If you don't rely on doctors' reports, what other method can you rely on? Can you rely on your census? It seems from our experience in North Carolina that the census is not at all satisfactory, taken either by trained men or by local organizations. If you don't accept the doctors' reports, I don't know what reports you can accept. It is not up to us to question a doctor's diagnoses; we have got to accept them. He may be wrong in some instances, but a mistake in one direction will be offset by a mistake in the other direction.

Mr. LE PRINCE. There are two or three matters that have been brought to my attention. I have been asked by some one present if arrangements could not be made to thank the Engineers and Architect's Club for the use of this room, the Nassau County Mosquito Extermination Commission, of New York, for sending a representative here, and also the Agricultural Department for sending Mr. McCrory here. If this meets with your approval such letters of thanks will be sent. All in favor will please rise. I think I am authorized to send those letters forward.

Dr. FRICKS. Gentlemen, I am sorry I could not have been with you every minute of the entire time you had for your conference here in the last two days, but I had other matters in which you are also interested, which had to be attended to.

I am extremely proud of this meeting. I do not take any credit to myself for having brought it about; the credit belongs to you, to the cooperating agencies which made this meeting possible, and to your chairman, whom we believe to be the first man in malaria-control work in the United States [great applause], and who is certainly the first in the regard of us all.

Mr. LE PRINCE. This conference stands adjourned until 12 months, more or less, from to-day.

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